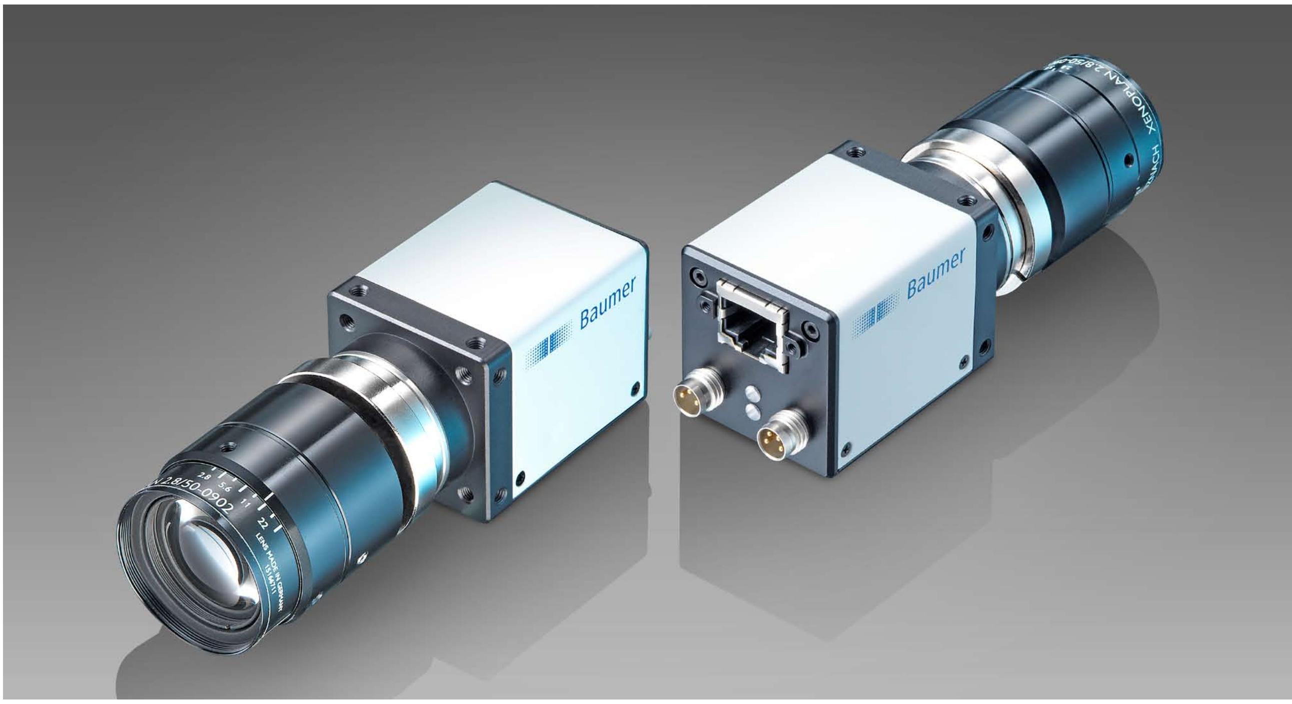
Baumer



Baumer TXG

User's Guide for Gigabit Ethernet Cameras

Table of Contents

1. Portfolio

All Baumer Gigabit Ethernet cameras of the TXG family are characterized by:

Best image quality

- High-quality progressive scan CCD sensors with highest sensitivity
- Image output data in 8 / 10 / 12 bit resolution
- Low noise and structure-free image information
- High quality mode with minimum noise

Flexible image acquisition

- Exposure times from 4 µs to 60.000 ms
- Binning and true partial scan readout modes
- Industrially compliant process interface with parameter setting capability (trigger and flash)

Fast image transfer

- Reliable transmission at 1000 Mbit/sec according to IEEE802.3
- Cable length up to 100 m
- Baumer driver for high data volume with low CPU load
- High-speed multi-camera operation
- Gen<I>Cam™ and GigE Vision® compliant

Perfect integration

- Flexible generic programming interface (Baumer-GAPI) for all Baumer cameras
- Powerful Software Development Kit (SDK) with sample codes and help files for simple integration
- Baumer viewer for all camera functions
- Interface for .NET (C#, VB.NET), C and C++
- Software for Windows® XP / Vista™ and Linux®, 32 bit and 64 bit
- Gen<I>Cam™ compliant XML file to describe the camera functions
- Supplied with installation program with automatic camera recognition for simple commissioning

Compact design

- Rugged, industrial housing design
- Uniform dimensions (36 mm x 36 mm frontside) for all standard models
- Light weight

Reliable operation

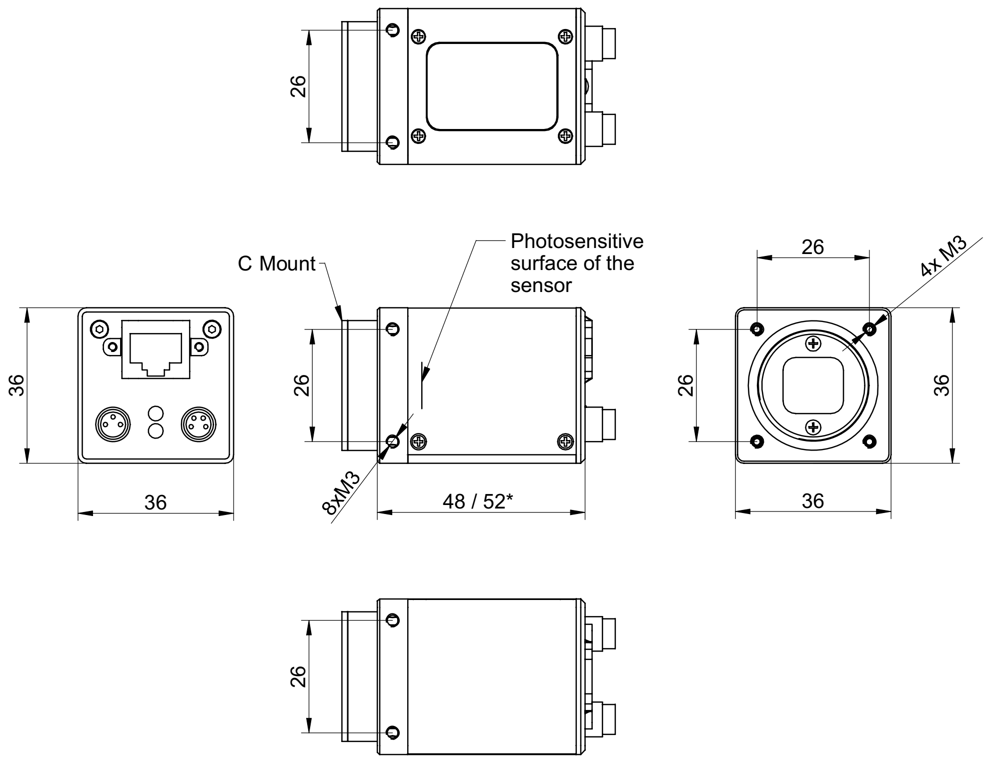
- State-of-the-art camera electronics and precision mechanics
- Low power consumption and minimal heat generation
- Long lifetime

1.1 Standard Cameras

◄ **Figure 1**
Front and rear view of a Baumer TXG camera.

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome / Color			
TXG02 / TXG02c	1/4"	656x494	140
TXG03 / TXG03c	1/3"	656 x 494 / 656 x 490	90
TXG04 / TXG04c	1/2"	656 x 494 / 656 x 490	56
TXG04h	1/3"	640 x 480	210
TXG06 / TXG06c	1/2"	776 x 582 / 776 x 578	64
TXG08 / TXG08c	1/3"	1032 x 776 / 1032 x 772	28
TXG12 / TXG12c	1/3"	1296 x 966	32
TXG13 / TXG13c	1/2"	1392 x 1040 / 1384 x 1036	20
TXG14 / TXG14c	2/3"	1392 x 1040 / 1384 x 1036	20
TXG14f / TXG14cf	2/3"	1392 x 1040 / 1384 x 1036	30
TXG20 / TXG20c	1/1.8"	1624 x 1236 / 1624 x 1232	16
TXG50 / TXG50c	2/3"	2448 x 2050 / 2448 x 2050	15

Dimensions



◄ **Figure 2**
Dimensions of a Baumer TXG camera.

* *true for Baumer TXG04h*

1.2 Standard Cameras with Power over Ethernet (PoE)

- Power over ethernet line
- Single cable solution for power, image data and parameterization
- External trigger possible

Figure 3 ►
Front and rear view of a Baumer TXG camera with Power over Ethernet (PoE).

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome / Color			
TXG03-P / TXG03c-P	1/3"	656 x 494 / 656 x 490	90
TXG04-P	1/2"	656 x 494	56
TXG06-P / TXG06c-P	1/2"	776 x 582 / 776 x 578	64
TXG08-P / TXG08c-P	1/3"	1032 x 776 / 1032 x 772	28
TXG13-P / TXG13c-P	1/2"	1392 x 1040 / 1384 x 1036	20
TXG14-P / TXG14c-P	2/3"	1392 x 1040 / 1384 x 1036	20
TXG14f-P / TXG14cf-P	2/3"	1392 x 1040 / 1384 x 1036	30
TXG20-P / TXG20c-P	1/1.8"	1624 x 1236 / 1624 x 1232	16
TXG50-P / TXG50c-P	2/3"	2448 x 2050 / 2448 x 2050	15

Dimensions

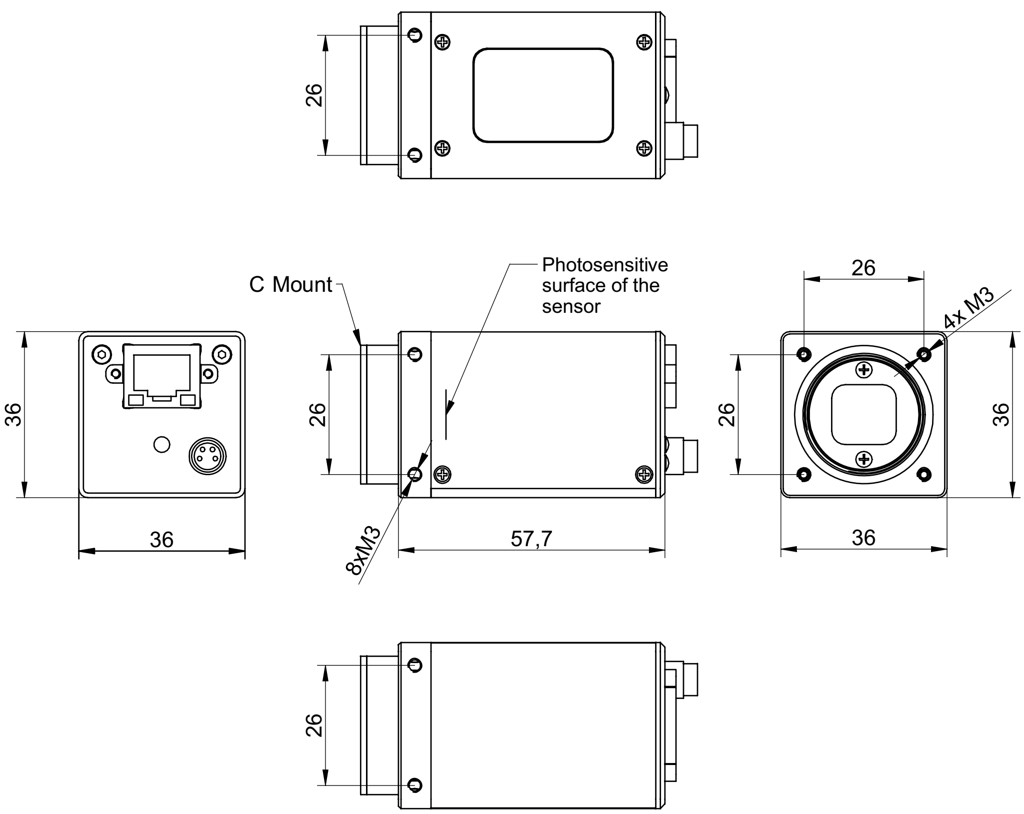


Figure 4 ►
Dimensions of a Baumer TXG camera with PoE.

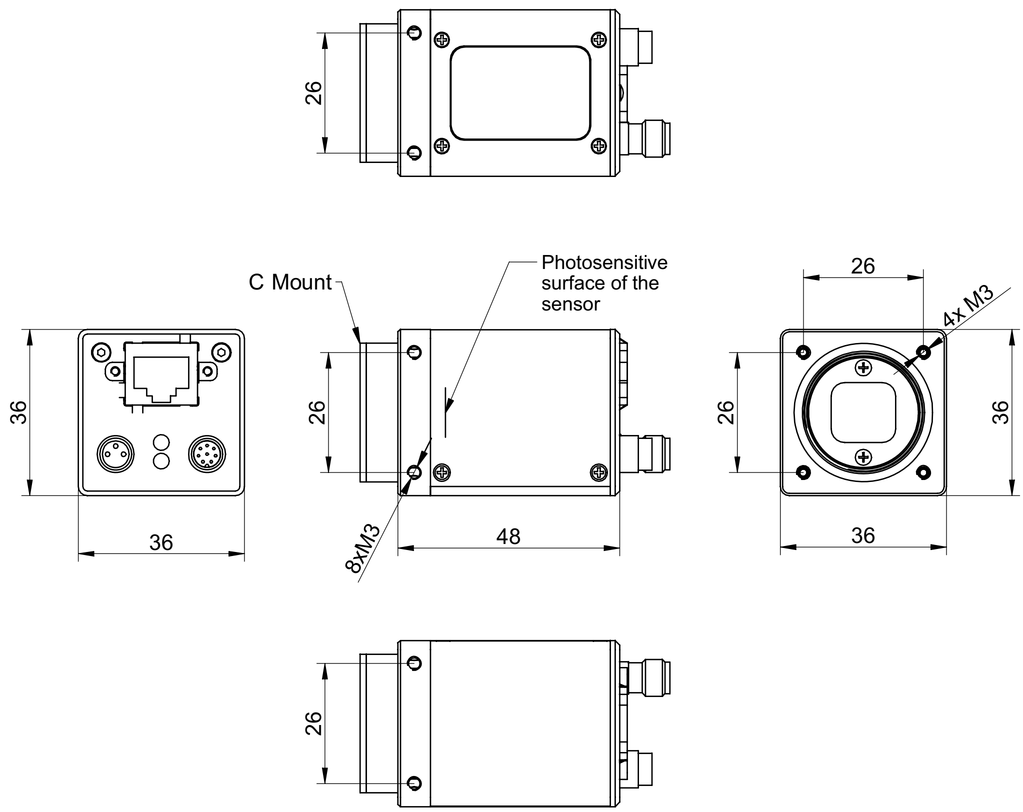
1.3 Standard Cameras with 3 In- and 3 Outputs

- Freely configurable inputs and outputs
- Each with 3 inputs and outputs
- PLC conform signal levels

◄ **Figure 5**
Front and rear view of a Baumer TXG camera with additional IOs (m3).

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome / Color			
TXG03m3 / TXG03cm3	1/3"	656 x 494 / 656 x 490	90
TXG04m3	1/2"	656 x 494	56
TXG06m3 / TXG06cm3	1/2"	776 x 582 / 776 x 578	64
TXG08m3 / TXG08cm3	1/3"	1032 x 776 / 1032 x 772	28
TXG13m3 / TXG13cm3	1/2"	1392 x 1040 / 1384 x 1036	20
TXG14m3 / TXG14cm3	2/3"	1392 x 1040 / 1384 x 1036	20
TXG14fm3	2/3"	1392 x 1040	30
TXG20m3 / TXG20cm3	1/1.8"	1624 x 1236 / 1624 x 1232	16
TXG50m3 / TXG50cm3	2/3"	2448 x 2050 / 2448 x 2050	15

Dimensions



◄ **Figure 6**
Dimensions of a Baumer TXG camera with additional IOs (m3).

1.4 IP67 Cameras

- Water- and dust-protected camera and lens
- Different tube length, depending on the lens
- Safe from accidental adjustment of the lens

Figure 7 ▶
Front and rear view of a Baumer TXG-I7 camera with IP67 housing

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
Monochrome / Color			
TXG03-I7 / TXG03c-I7	1/3"	656 x 494 / 656 x 490	90
TXG04-I7 / TXG04c-I7	1/2"	656 x 494 / 656 x 490	56
TXG06-I7 / TXG06c-I7	1/2"	776 x 582 / 776 x 578	64
TXG08-I7 / TXG08c-I7	1/3"	1032 x 776 / 1032 x 772	28
TXG13-I7 / TXG13c-I7	1/2"	1392 x 1040 / 1384 x 1036	20
TXG14-I7 / TXG14c-I7	2/3"	1392 x 1040 / 1384 x 1036	20
TXG14f-I7	2/3"	1392 x 1040	30
TXG20-I7 / TXG20c-I7	1/1.8"	1624 x 1236 / 1624 x 1232	16
TXG50-I7 / TXG50c-I7	2/3"	2448 x 2050 / 2448 x 2050	15

Camera Dimensions

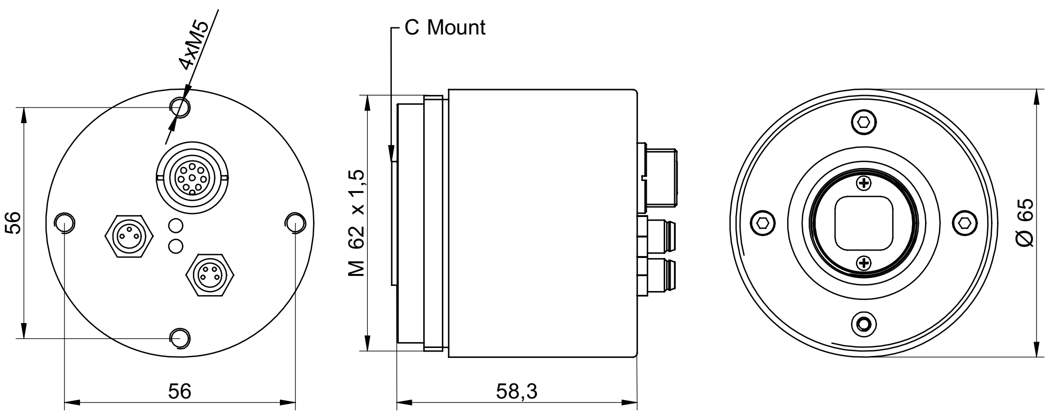
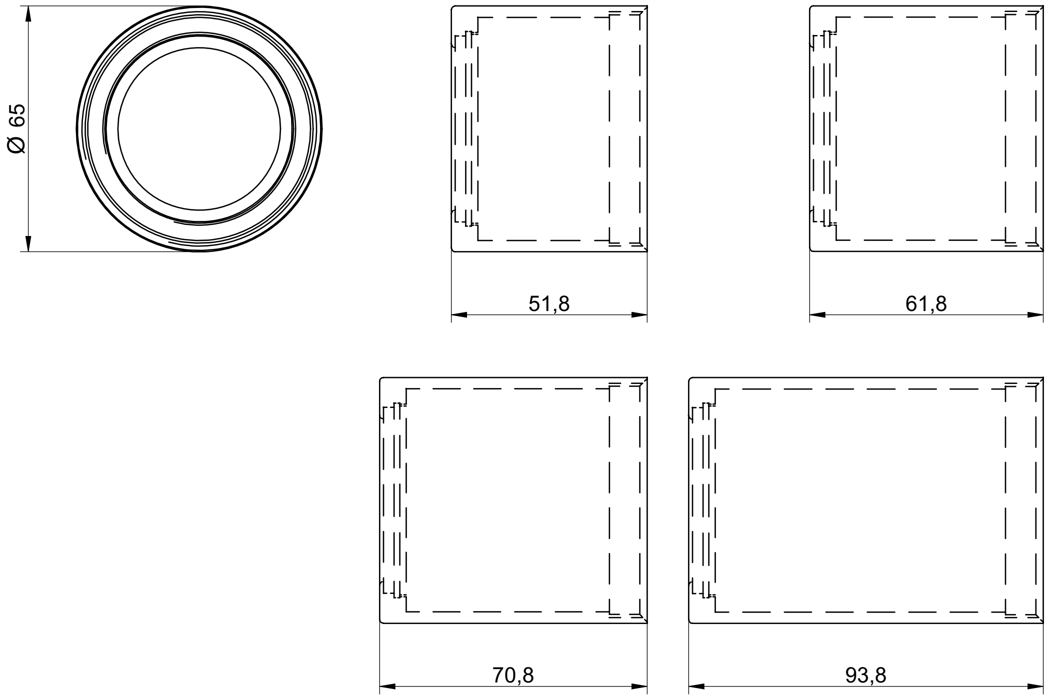


Figure 8 ▶
Dimensions of a Baumer TXG-I7 camera with IP67 housing.

1.4.1 Protective Caps

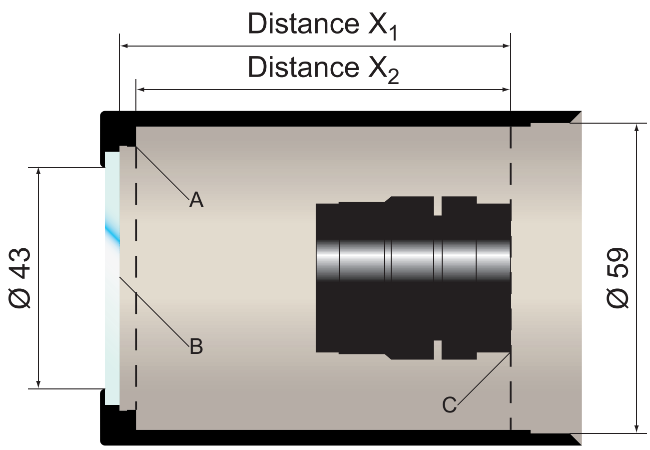
◄ **Figure 9**
Available protective caps for Baumer TXG-I7 cameras.

Protective Cap Dimensions



◄ **Figure 10**
Dimensions of available protective caps for IP67 housing.

1.4.2 Maximal Objective Length inside Protective Cap



A - Cylinder bottom
B - Cover glass
C - C-mount

◄ **Figure 11**
Maximal objective legth inside protective caps for IP67 housing.

Tube Length [mm]	Item Number	Distance X_1 [mm]	Distance X_2 [mm]
51,8	11008777	32,6	30
61,8	11008776	42,6	40
70,8	11008775	51,6	49
93,8	11008774	74,6	72

1.4.3 Determination of the Required Tube Length

1.4.3.1 Cameras with Sensor Size of 1/3"[*)]

Manufacturer	Model	Tube Length [mm]			
		51.8	61.8	70.8	93.8
Pentax	C60607 - H612A	□	□	■	□
Pentax	C31634KP C1614-M	□	■	■	■
Pentax	C32500KP C2514-M (KP)	□	■	■	■
Pentax	C33500KP C3516-M (KP)	□	■	■	■
Pentax	C35001KP C5028-M (KP)	□	■	■	■
Pentax	C37500KP C7528-M (KP)	□	□	□	■
Pentax	C31630KP C1614A (KP)	□	■	■	■
Pentax	C30405KP C418DX (KP)	□	■	□	□
Pentax	C30811KP C815B (KP)	□	□	■	□
Pentax	C61232KP H1214-M (KP)	■	■	■	■
Pentax	C62500 H2520-UVM (KP)	□	□	■	■
Pentax	C61215KP H1212B (KP)	□	■	■	■
Pentax	C91608KG H614-M (KP)	□	■	■	□
Linos	MeVis C 12mm / 1.8	□	□	□	■
Linos	MeVis C 16mm / 1.6	□	□	□	■
Linos	MeVis C 25mm / 1.6	□	□	■	■
Linos	MeVis C 35mm / 1.6	□	□	■	■
Linos	MeVis C 50mm / 1.8	□	□	□	■
Schneider Kreuznach	CNG 1.8/4.8	□	■	□	□
Schneider Kreuznach	CNG 1.4/8	□	■	■	□
Schneider Kreuznach	CNG 1.4/12	□	□	■	■
Schneider Kreuznach	XNP 1.4/17	□	■	■	■
Schneider Kreuznach	XNP 1.4/23	□	■	■	■
Schneider Kreuznach	XNP 1.9/35	□	■	■	■
Schneider Kreuznach	CNG 1,9/10	□	□	■	■
Schneider Kreuznach	CNG 1,8/16	□	□	■	■
Schneider Kreuznach	XNP 2.0/28	□	■	■	■
Schneider Kreuznach	XNP 2.8/50	□	□	□	■
Tamron	219HB	■	■	■	□
Tamron	25HB	■	■	■	□
Tamron	17HF	■	■	■	■
Tamron	20HC	■	■	■	■
Tamron	35HB	■	■	■	■
Tamron	21HC	□	■	■	■
Tamron	1A1HB	□	□	□	■

*) Calculation without spacer ring!
No guarantee for correctness!
Refraction of light at the cover glass of the tube may cause a slight dislocation of the focus level!

1.4.3.2 Cameras with Sensor Size of 2/3"*)

Manufacturer	Model	Tube Length [mm]			
		51.8	61.8	70.8	93.8
Pentax	C60607 - H612A	□	□	□	□
Pentax	C31634KP C1614-M	□	■	■	□
Pentax	C32500KP C2514-M (KP)	□	■	■	■
Pentax	C33500KP C3516-M (KP)	□	■	■	■
Pentax	C35001KP C5028-M (KP)	□	■	■	■
Pentax	C37500KP C7528-M (KP)	□	□	□	■
Pentax	C31630KP C1614A (KP)	□	■	■	□
Pentax	C30405KP C418DX (KP)	□	□	□	□
Pentax	C30811KP C815B (KP)	□	□	□	□
Pentax	C61232KP H1214-M (KP)	■	□	□	□
Pentax	C62500 H2520-UVM (KP)	□	□	■	■
Pentax	C61215KP H1212B (KP)	□	■	□	□
Pentax	C91608KG H614-M (KP)	□	□	□	□
Linos	MeVis C 12mm / 1.8	□	□	□	■
Linos	MeVis C 16mm / 1.6	□	□	□	■
Linos	MeVis C 25mm / 1.6	□	□	■	■
Linos	MeVis C 35mm / 1.6	□	□	■	□
Linos	MeVis C 50mm / 1.8	□	□	□	□
Schneider Kreuznach	CNG 1.8/4.8	□	□	□	□
Schneider Kreuznach	CNG 1.4/8	□	□	□	□
Schneider Kreuznach	CNG 1.4/12	□	□	□	□
Schneider Kreuznach	XNP 1.4/17	□	■	■	□
Schneider Kreuznach	XNP 1.4/23	□	■	■	■
Schneider Kreuznach	XNP 1.9/35	□	■	■	■
Schneider Kreuznach	CNG 1,9/10	□	□	■	□
Schneider Kreuznach	CNG 1,8/16	□	□	■	□
Schneider Kreuznach	XNP 2.0/28	□	■	■	■
Schneider Kreuznach	XNP 2.8/50	□	□	□	■
Tamron	219HB	■	□	□	□
Tamron	25HB	■	□	□	□
Tamron	17HF	■	■	■	□
Tamron	20HC	■	■	■	■
Tamron	35HB	■	■	■	■
Tamron	21HC	□	■	■	■
Tamron	1A1HB	□	□	□	■

*) Calculation without spacer ring!
No guarantee for correctness!
Refraction of light at the cover glass of the tube may cause a slight dislocation of the focus level!

1.4.3.3 Cameras with Sensor Size of 1/2"*)

Manufacturer	Model	Tube Length [mm]			
		51.8	61.8	70.8	93.8
Pentax	C60607 - H612A	□	□	□	□
Pentax	C31634KP C1614-M	□	■	■	□
Pentax	C32500KP C2514-M (KP)	□	■	■	■
Pentax	C33500KP C3516-M (KP)	□	■	■	■
Pentax	C35001KP C5028-M (KP)	□	■	■	■
Pentax	C37500KP C7528-M (KP)	□	□	□	■
Pentax	C31630KP C1614A (KP)	□	■	■	□
Pentax	C30405KP C418DX (KP)	□	□	□	□
Pentax	C30811KP C815B (KP)	□	□	□	□
Pentax	C61232KP H1214-M (KP)	■	■	□	□
Pentax	C62500 H2520-UVM (KP)	□	□	■	■
Pentax	C61215KP H1212B (KP)	□	■	■	□
Pentax	C91608KG H614-M (KP)	□	□	□	□
Linos	MeVis C 12mm / 1.8	□	□	□	■
Linos	MeVis C 16mm / 1.6	□	□	□	■
Linos	MeVis C 25mm / 1.6	□	□	■	■
Linos	MeVis C 35mm / 1.6	□	□	■	■
Linos	MeVis C 50mm / 1.8	□	□	□	■
Schneider Kreuznach	CNG 1.8/4.8	□	□	□	□
Schneider Kreuznach	CNG 1.4/8	□	■	□	□
Schneider Kreuznach	CNG 1.4/12	□	□	■	□
Schneider Kreuznach	XNP 1.4/17	□	■	■	■
Schneider Kreuznach	XNP 1.4/23	□	■	■	■
Schneider Kreuznach	XNP 1.9/35	□	■	■	■
Schneider Kreuznach	CNG 1,9/10	□	□	■	□
Schneider Kreuznach	CNG 1,8/16	□	□	■	■
Schneider Kreuznach	XNP 2.0/28	□	■	■	■
Schneider Kreuznach	XNP 2.8/50	□			■
Tamron	219HB	■	□	□	□
Tamron	25HB	■	■	□	□
Tamron	17HF	■	■	■	□
Tamron	20HC	■	■	■	■
Tamron	35HB	■	■	■	■
Tamron	21HC	□	■	■	■
Tamron	1A1HB	□	□	□	■

*) Calculation without spacer ring!
No guarantee for correctness!
Refraction of light at the cover glass of the tube may cause a slight dislocation of the focus level!

1.4.3.4 Cameras with Sensor Size of 1/1.8"*)

Manufacturer	Model	Tube Length [mm]			
		51.8	61.8	70.8	93.8
Pentax	C60607 - H612A	□	□	□	□
Pentax	C31634KP C1614-M	□	■	■	□
Pentax	C32500KP C2514-M (KP)	□	■	■	■
Pentax	C33500KP C3516-M (KP)	□	■	■	■
Pentax	C35001KP C5028-M (KP)	□	■	■	■
Pentax	C37500KP C7528-M (KP)	□	□	□	■
Pentax	C31630KP C1614A (KP)	□	■	■	□
Pentax	C30405KP C418DX (KP)	□	□	□	□
Pentax	C30811KP C815B (KP)	□	□	□	□
Pentax	C61232KP H1214-M (KP)	■	■	□	□
Pentax	C62500 H2520-UVM (KP)	□	□	■	■
Pentax	C61215KP H1212B (KP)	□	■	■	□
Pentax	C91608KG H614-M (KP)	□	□	□	□
Linos	MeVis C 12mm / 1.8	□	□	□	■
Linos	MeVis C 16mm / 1.6	□	□	□	■
Linos	MeVis C 25mm / 1.6	□	□	■	■
Linos	MeVis C 35mm / 1.6	□	□	■	□
Linos	MeVis C 50mm / 1.8	□	□	□	□
Schneider Kreuznach	CNG 1.8/4.8	□	□	□	□
Schneider Kreuznach	CNG 1.4/8	□	□	□	□
Schneider Kreuznach	CNG 1.4/12	□	□	□	□
Schneider Kreuznach	XNP 1.4/17	□	■	■	□
Schneider Kreuznach	XNP 1.4/23	□	■	■	■
Schneider Kreuznach	XNP 1.9/35	□	■	■	■
Schneider Kreuznach	CNG 1,9/10	□	□	■	□
Schneider Kreuznach	CNG 1,8/16	□	□	■	□
Schneider Kreuznach	XNP 2.0/28	□	■	■	■
Schneider Kreuznach	XNP 2.8/50	□	□	□	■
Tamron	219HB	□	□	□	□
Tamron	25HB	■	□	□	□
Tamron	17HF	■	■	■	□
Tamron	20HC	■	■	■	■
Tamron	35HB	■	■	■	■
Tamron	21HC	□	■	■	■
Tamron	1A1HB	□	□	□	■

*) Calculation without spacer ring!
No guarantee for correctness!
Refraction of light at the cover glass of the tube may cause a slight dislocation of the focus level!

2. Product Specifications

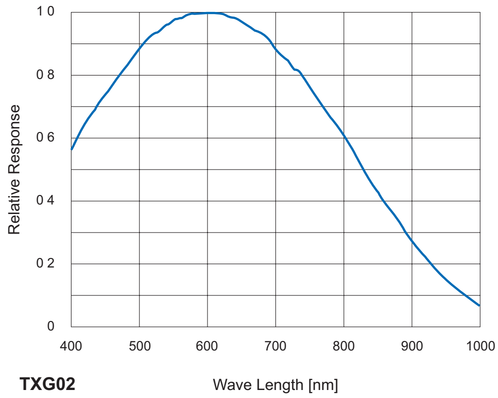
2.1 Spectral Sensitivity for Baumer TXG Cameras

The spectral sensitivity characteristics of monochrome and color matrix sensors for Baumer Gigabit Ethernet cameras are displayed in the following graphs. The characteristic curves for the sensors do not take the characteristics of lenses and light sources without filters into consideration.

Values relating to the respective technical data sheets of SONY Corporation.

Figure 12 ▶
Spectral sensitivities for Baumer cameras with 0.3 MP*) CCD sensor.

*) MP = Megapixels



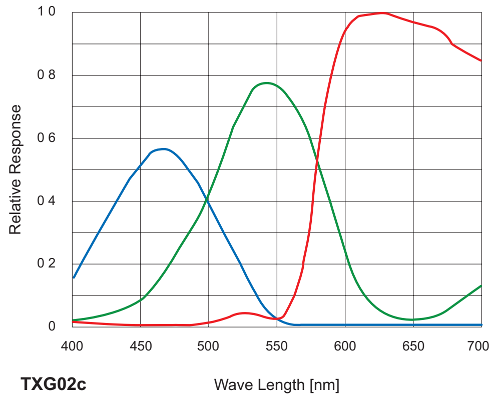
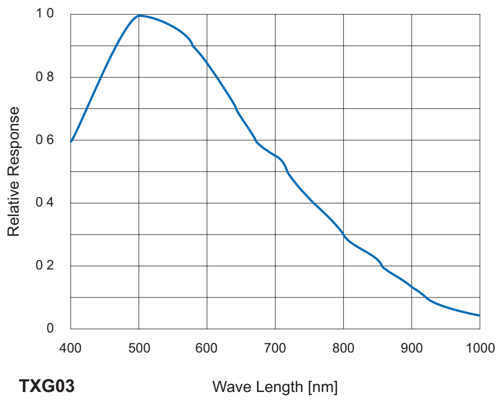


Figure 13 ▶
Spectral sensitivities for Baumer cameras with 0.3 MP CCD sensor.



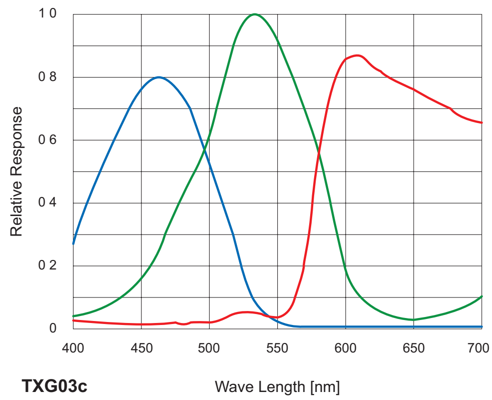
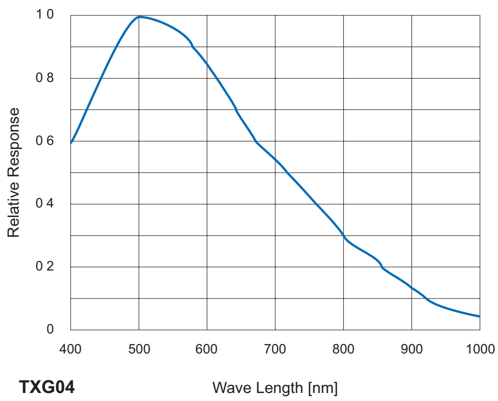
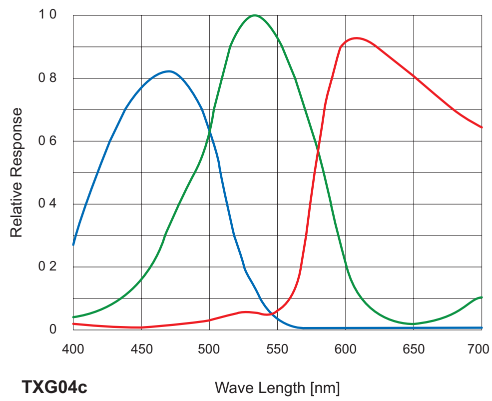
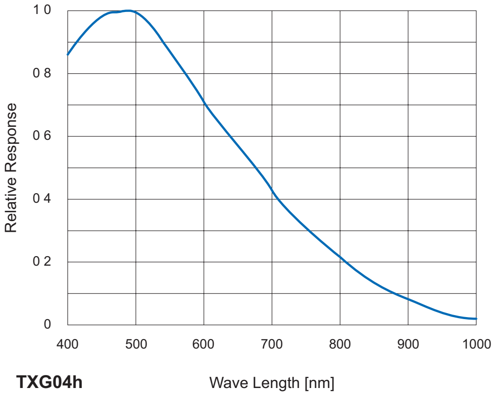


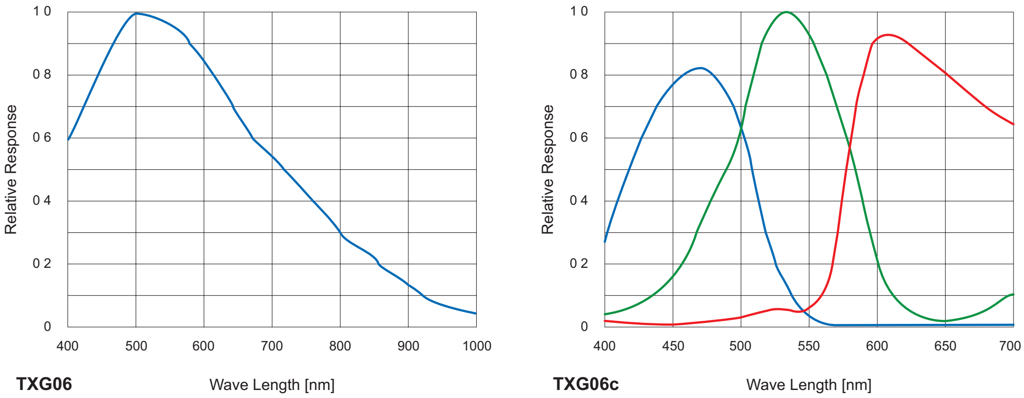
Figure 14 ▶
Spectral sensitivities for Baumer cameras with 0.3 MP CCD sensor.



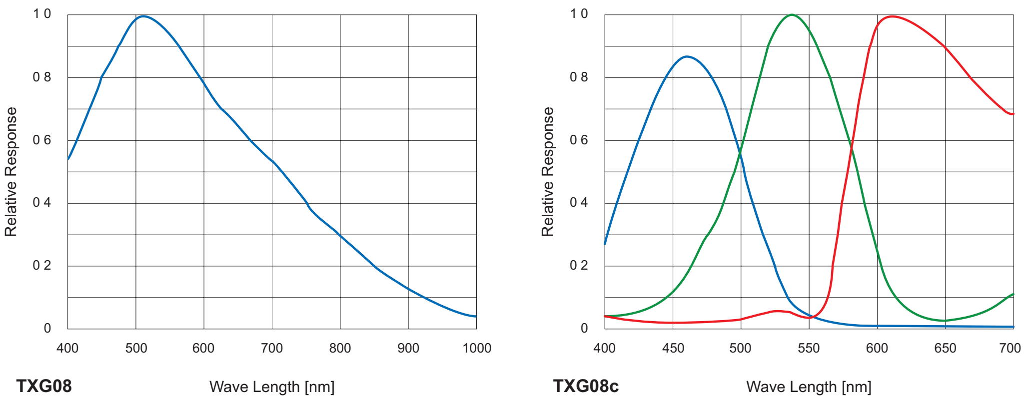




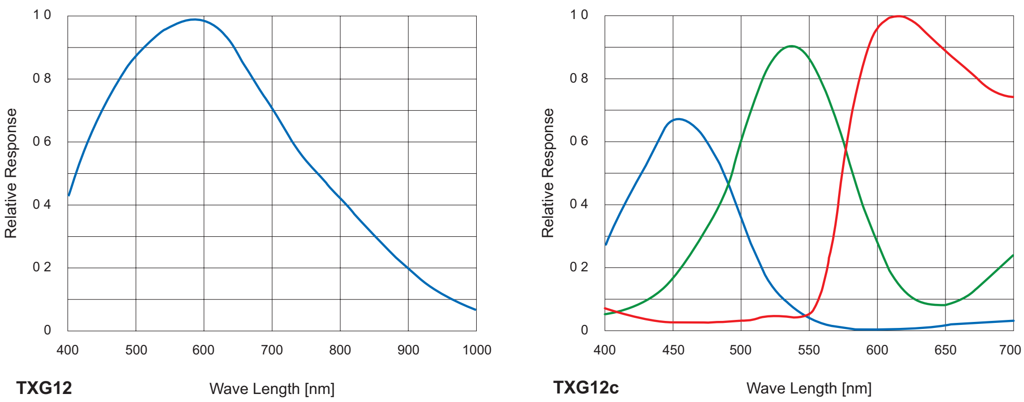
◀ **Figure 15**
Spectral sensitivities for Baumer cameras with 0.3 MP Kodak CCD sensor.



◀ **Figure 16**
Spectral sensitivities for Baumer cameras with 0.6 MP CCD sensor.



◀ **Figure 17**
Spectral sensitivities for Baumer cameras with 0.8 MP CCD sensor.



◀ **Figure 18**
Spectral sensitivities for Baumer cameras with 1,2 MP CCD sensor.

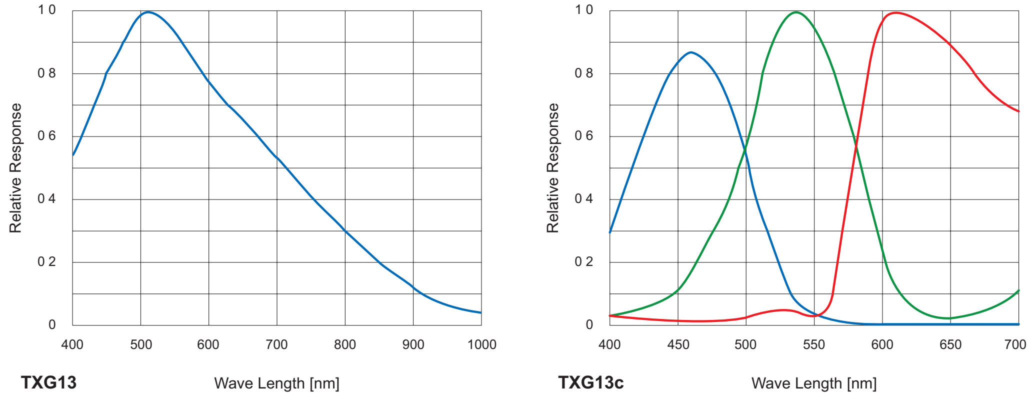


Figure 19 ▶
Spectral sensitivities for Baumer cameras with 1.4 MP CCD sensor.

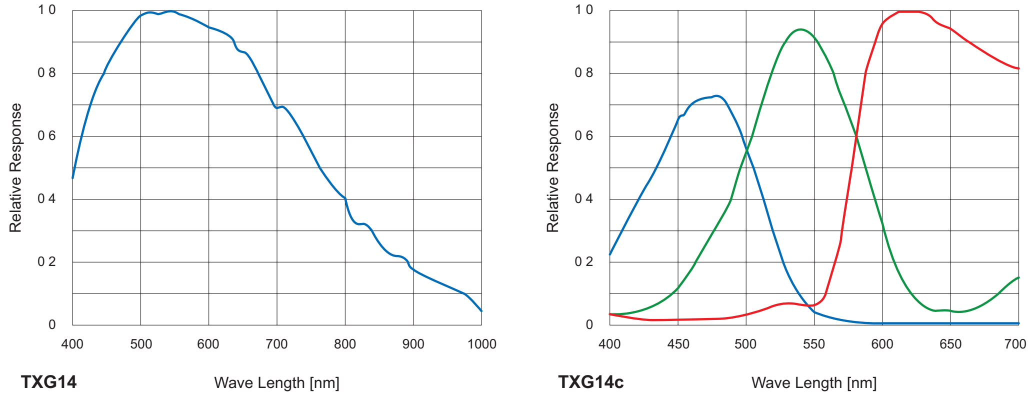


Figure 20 ▶
Spectral sensitivities for Baumer cameras with 1.4 MP CCD sensor.

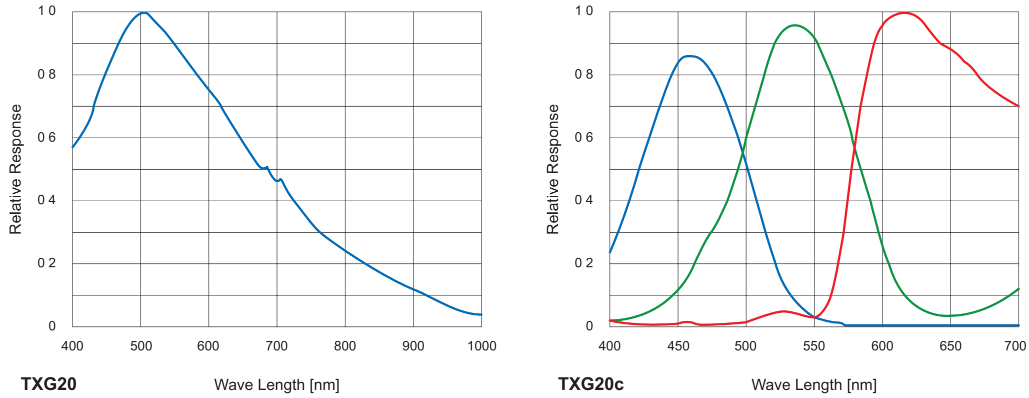


Figure 21 ▶
Spectral sensitivities for Baumer cameras with 2.0 MP CCD sensor.

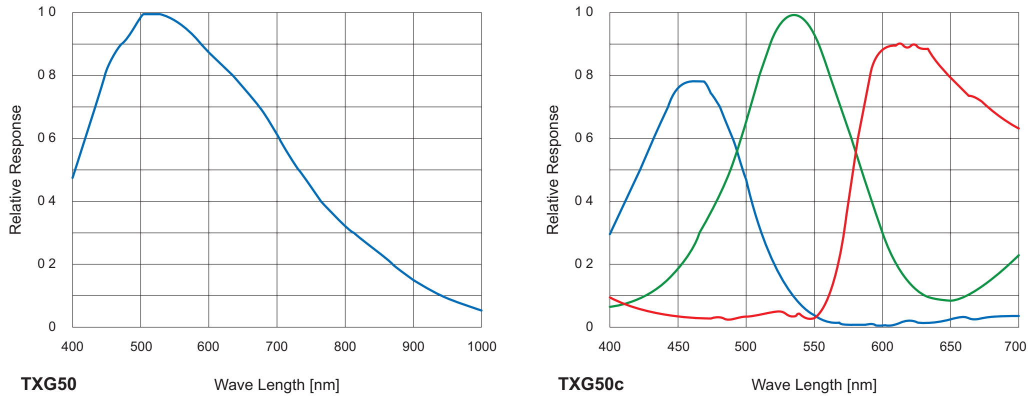
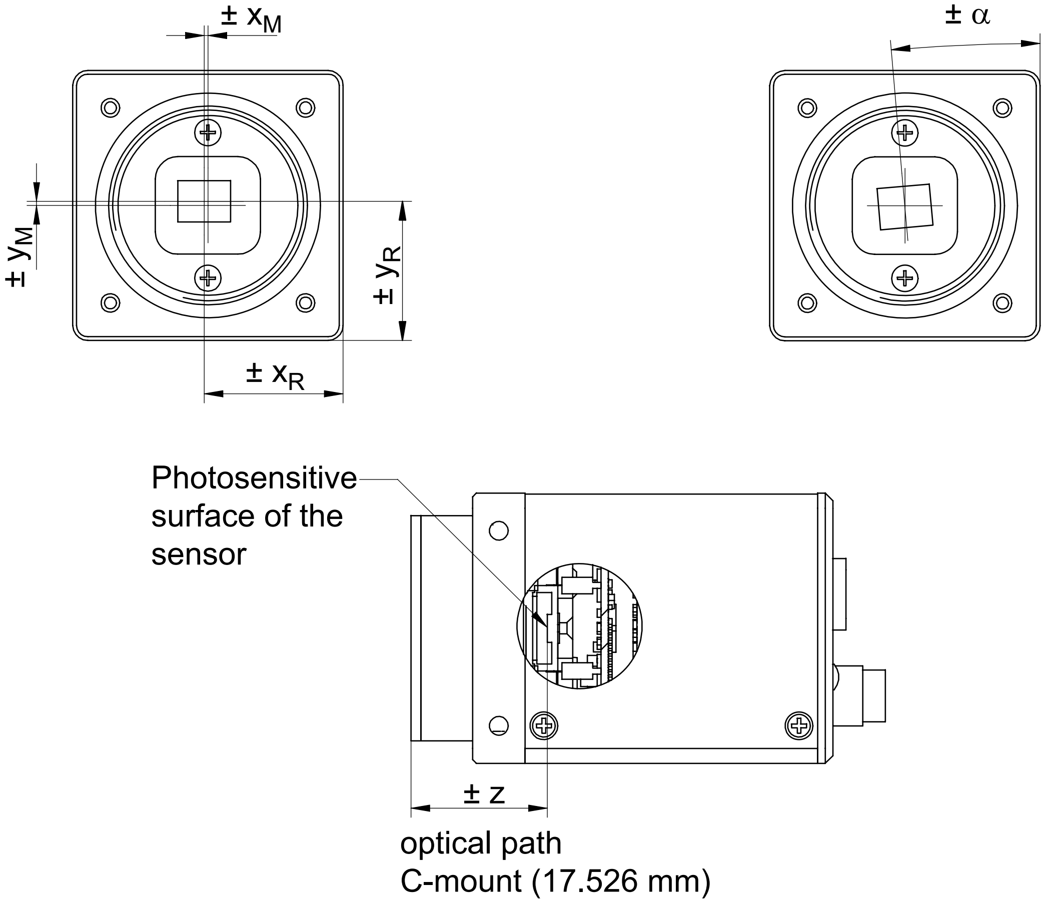


Figure 22 ▶
Spectral sensitivities for Baumer cameras with 5.0 MP CCD sensor.

2.2 Field of View Position

2.2.1 Standard Cameras

The typical accuracy by assumption of the root mean square value is displayed in the figures and the table below:



◄ **Figure 23**
Sensor accuracy of Baumer TXG cameras.

Camera Type	$\pm x_{M,typ}$ [mm]	$\pm y_{M,typ}$ [mm]	$\pm x_{R,typ}$ [mm]	$\pm y_{R,typ}$ [mm]	$\pm \alpha_{typ}$ [°]	$\pm z_{typ}$ [mm]
TXG03	0,07	0,07	0,1	0,1	0,7	0,025
TXG02	0,07	0,07	0,1	0,1	0,7	0,025
TXG04	0,07	0,07	0,1	0,1	0,7	0,025
TXG04h	0,17	0,17	0,19	0,19	1,4	0,025
TXG06	0,07	0,07	0,1	0,1	0,7	0,025
TXG08	0,07	0,07	0,1	0,1	0,7	0,025
TXG12	0,05	0,05	0,08	0,08	0,7	0,025
TXG13	0,05	0,05	0,08	0,08	0,7	0,025
TXG14	0,1	0,1	0,13	0,13	0,8	0,025
TXG20	0,05	0,05	0,08	0,08	0,7	0,025
TXG50	0,05	0,05	0,08	0,08	0,7	0,025

2.2.2 Cameras with IP67 Housing

The typical accuracy by assumption of the root mean square value is displayed in the figures and the table below:

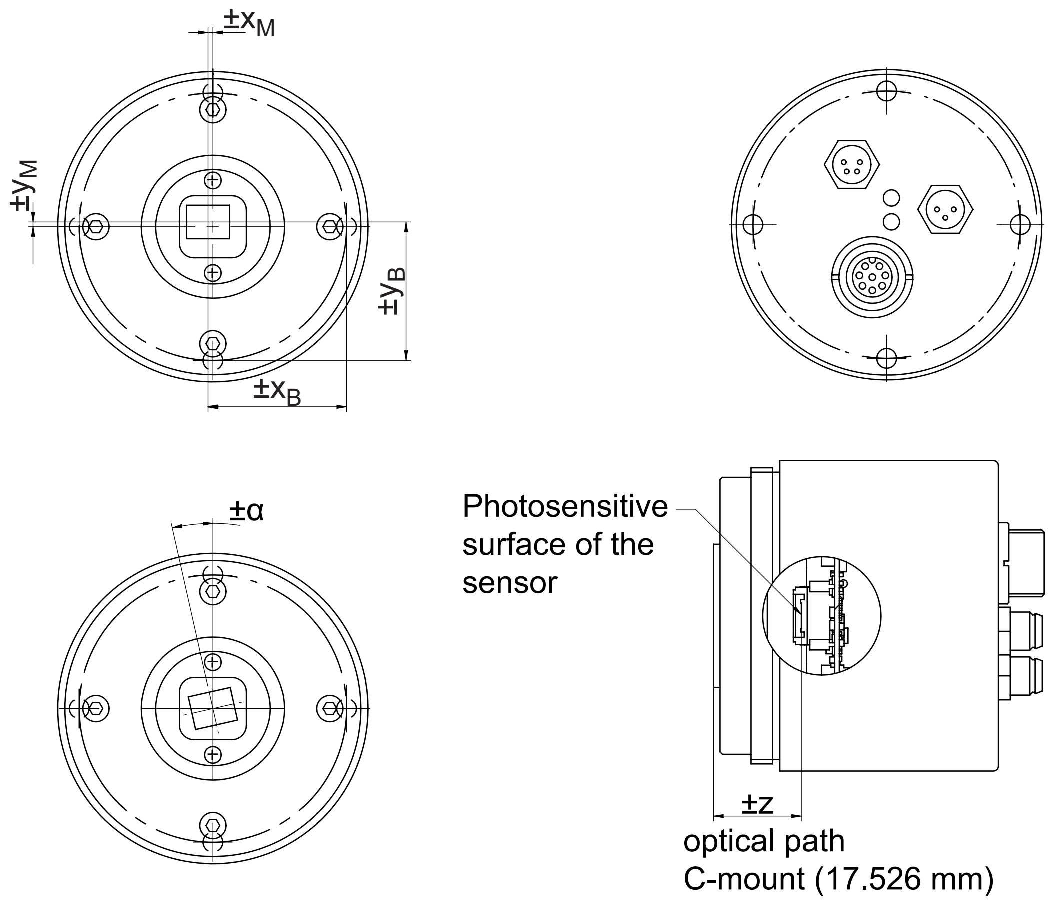


Figure 24 ►
Sensor accuracy of Baumer TXG-I7 cameras.

Camera Type	$\pm x_{M,typ}$ [mm]	$\pm y_{M,typ}$ [mm]	$\pm x_{B,typ}$ [mm]	$\pm y_{B,typ}$ [mm]	$\pm \alpha_{typ}$ [°]	$\pm z_{typ}$ [mm]
TXG03-I7	0,07	0,07	0,08	0,08	0,75	0,025
TXG06-I7	0,07	0,07	0,08	0,08	0,75	0,025
TXG08-I7	0,07	0,07	0,08	0,08	0,75	0,025
TXG13-I7	0,05	0,05	0,06	0,06	0,75	0,025
TXG14-I7	0,1	0,1	0,1	0,1	0,85	0,025
TXG20-I7	0,05	0,05	0,06	0,06	0,75	0,025
TXG50-I7	0,05	0,05	0,06	0,06	0,75	0,025

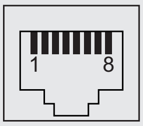
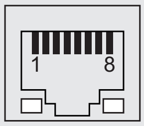
2.3 Process- and Data Interfaces

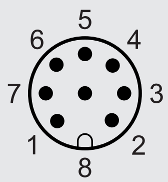
2.3.1 Interfaces of Camera Types

Camera Type	8P8C mod jack	8P8C mod jack LED	M8 3 pins	M8 4 pins	M8 8 pins	M12 8 pins
Standard	■	□	■	■	□	□
PoE	□	■	□	■	□	□
I7	□	□	■	■	□	■
E7	□	□	■	■	□	■
m3	□	□	■	□	■	□

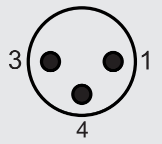
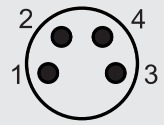
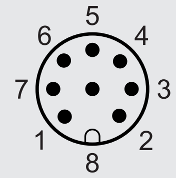
2.3.2 Pin-Assignment

2.3.2.1 Gigabit Ethernet Interface

8P8C mod jack			8P8C mod jack with LED			
						
1	(gn/wh)	MX1+	1	(gn/wh)	MX1+	(negative / positive V_{port})
2	(gn)	MX1-	2	(gn)	MX1-	(negative / positive V_{port})
3	(og/wh)	MX2+	3	(og/wh)	MX2+	(positive / negative V_{port})
4	(bu)	MX3+	4	(bu)	MX3+	
5	(bu/wh)	MX3-	5	(bu/wh)	MX3-	
6	(og)	MX2-	6	(og)	MX2-	(positive / negative V_{port})
7	(bn/wh)	MX4+	7	(bn/wh)	MX4+	
8	(bn)	MX4-	8	(bn)	MX4-	

M12 / 8 pins		
		
1	(white)	MX3-
2	(brown)	MX4+
3	(green)	MX4-
4	(yellow)	MX1-
5	(grey)	MX2+
6	(pink)	MX1+
7	(blue)	MX3+
8	(red)	MX2-

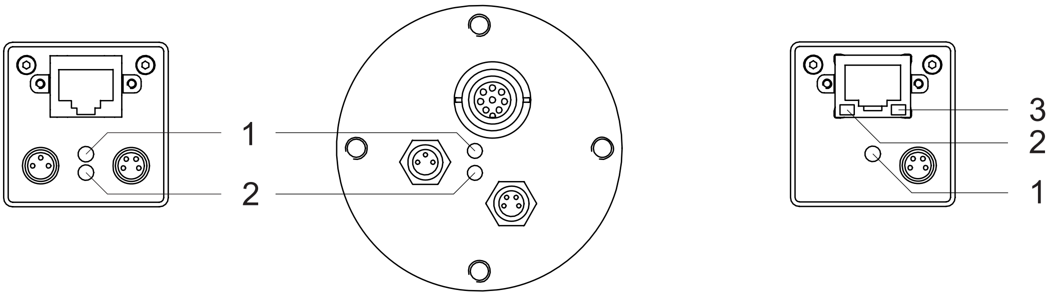
2.3.2.2 Power Supply and Digital IOs

M8 / 3 pins			M8 / 4 pins			M8 / 8 pins		
								
1	(brown)	Power V_{CC}	1	(brown)	TrigIN+	1	(white)	Out 3
3	(blue)	GND	2	(white)	TrigIN-	2	(brown)	In 2
4	(black)	NC	3	(blue)	Flash$_{out}$	3	(green)	In 1
			4	(black)	U_{ext}	4	(yellow)	IO GND
						5	(green)	IO Power V_{CC}
						6	(pink)	Out 1
						7	(blue)	Out 2
						8	(red)	In 3

2.3.3 LEDs of Camera Types

Camera Type	2 LEDs	3 LEDs
Standard	■	□
PoE	□	■
I7	■	□
E7	■	□
m3	■	□

2.3.3.1 LED Signaling



◄ **Figure 25**
LED positions on Baumer TXG cameras.

2 LEDs	Signal	Meaning
1	green	Power on
	yellow	Readout active
2	green	Link active
	green flash	Receiving
	yellow	Transmitting
	yellow / red flash	Receiving and Transmitting

3 LEDs	Signal	Meaning
1	green	Power on
	yellow	Readout active
2	green	Link active
	green flash	Receiving
3	red	Transmitting

2.4 Acquisition Modes and Timings

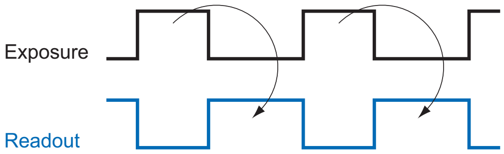
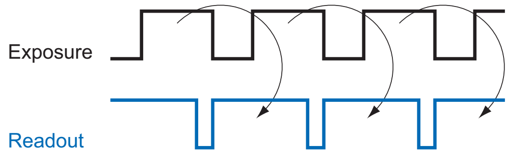
The image acquisition consists of two seperate, successively processed components.

Exposing the pixels on the photosensitive surface of the sensor is only the first part of the image acquisition. After completion of the first step, the pixels are read out.

Thereby the exposure time ($t_{exposure}$) can be adjusted by the user, however, the time needed for the readout ($t_{readout}$) is given by the particular sensor and image format.

Baumer cameras can be operated with three modes, the Free Running Mode, the Fixed-Frame-Rate Mode and the Trigger Mode.

The cameras can be operated non-overlapped*) or overlapped. Depending on the mode used, and the combination of exposure and readout time:

Non-overlapped Operation	Overlapped Operation
Here the time intervals are long enough to process exposure and readout successively.	In this operation the exposure of a frame (n+1) takes place during the readout of frame (n).
	

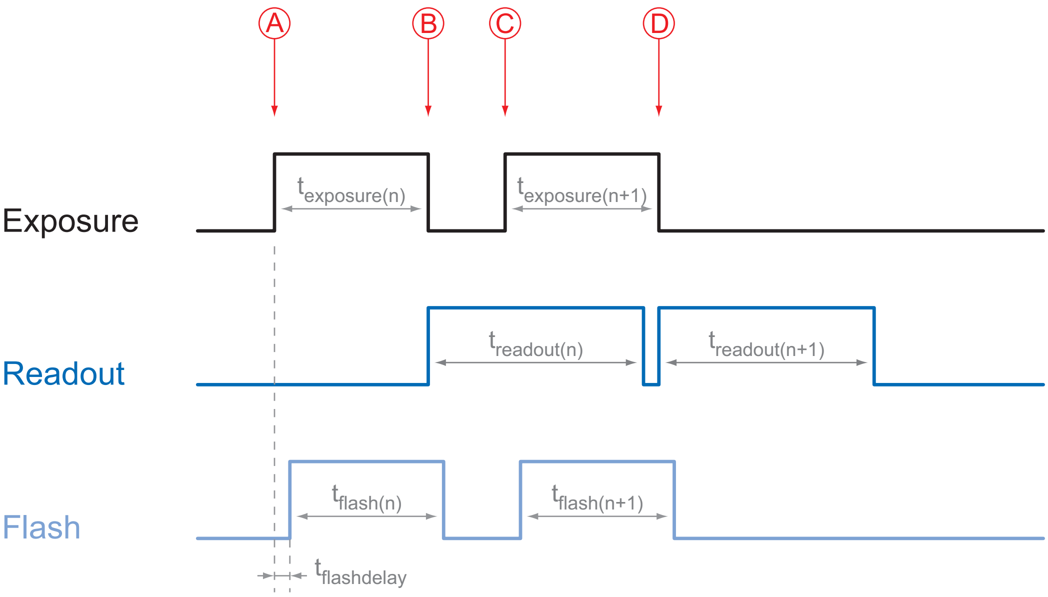
2.4.1 Free Running Mode

In the "Free Running" mode the camera records images permanently and sends them to the PC. In order to achieve an optimal (with regard to the adjusted exposure time $t_{exposure}$ and image format) the camera is operated overlapped.

In case of exposure times equal to / less than the readout time ($t_{exposure} \leq t_{readout}$), the maximum frame rate is provided for the image format used. For longer exposure times the frame rate of the camera is reduced.

Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective

Image parameters:
Offset
Gain
Mode
Partial Scan



$t_{flash} = t_{exposure}$

2.4.2 Fixed-Frame-Rate Mode

With this feature Baumer introduces a clever technique to the TXG camera series, that enables the user to predefine a desired frame rate in continous mode.

For the employment of this mode the cameras are equipped with an internal clock generator that creates trigger pulses.

Notice
From a certain frame rate, skipping internal triggers is unavoidable. In general, this depends on the combination of adjusted frame rate, exposure and readout times.

*) Non-overlapped means the same as sequential.

2.4.3 Trigger Mode

After a specified external event (trigger) has occurred, image acquisition is started. Depending on the interval of triggers used, the camera operates non-overlapped or overlapped in this mode.

With regard to timings in the trigger mode, the following basic formulas need to be taken into consideration:

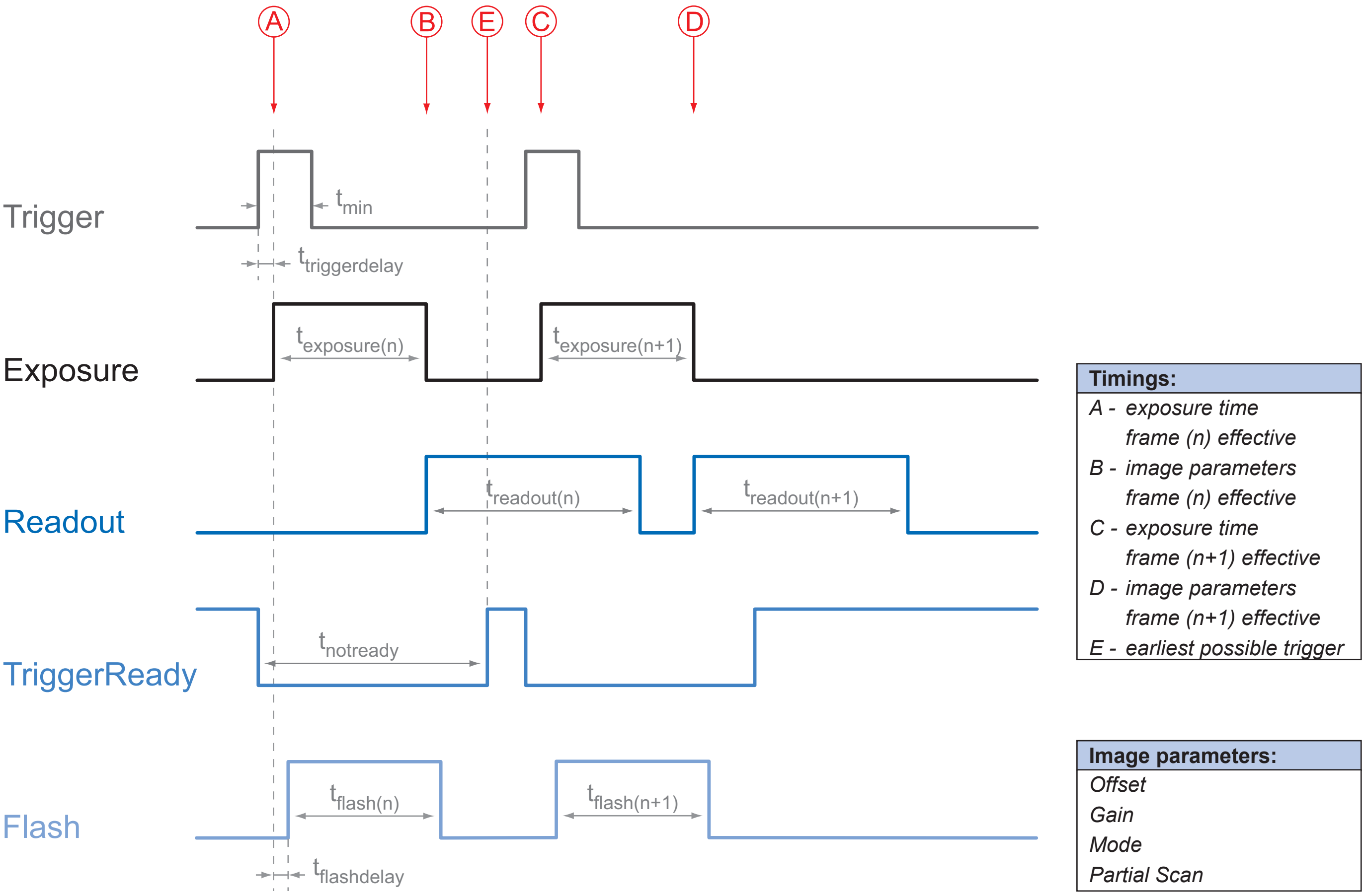
Case		Formula
$t_{exposure} < t_{readout}$	(1)	$t_{earliestpossibletrigger(n+1)} = t_{readout(n)} - t_{exposure(n+1)}$
	(2)	$t_{notready(n+1)} = t_{exposure(n)} + t_{readout(n)} - t_{exposure(n+1)}$
$t_{exposure} > t_{readout}$	(3)	$t_{earliestpossibletrigger(n+1)} = t_{exposure(n)}$
	(4)	$t_{notready(n+1)} = t_{exposure(n)}$

2.4.3.1 Overlapped Operation: $t_{exposure(n+2)} = t_{exposure(n+1)}$

In overlapped operation attention should be paid to the time interval where the camera is unable to process occuring trigger signals ($t_{notready}$). This interval is situated between two exposures. When this process time $t_{notready}$ has elapsed, the camera is able to react to external events again.

After $t_{notready}$ has elapsed, the timing of (E) depends on the readout time of the current image ($t_{readout(n)}$) and exposure time of the next image ($t_{exposure(n+1)}$). It can be determined by the formulas mentioned above (no. 1 or 3, as is the case).

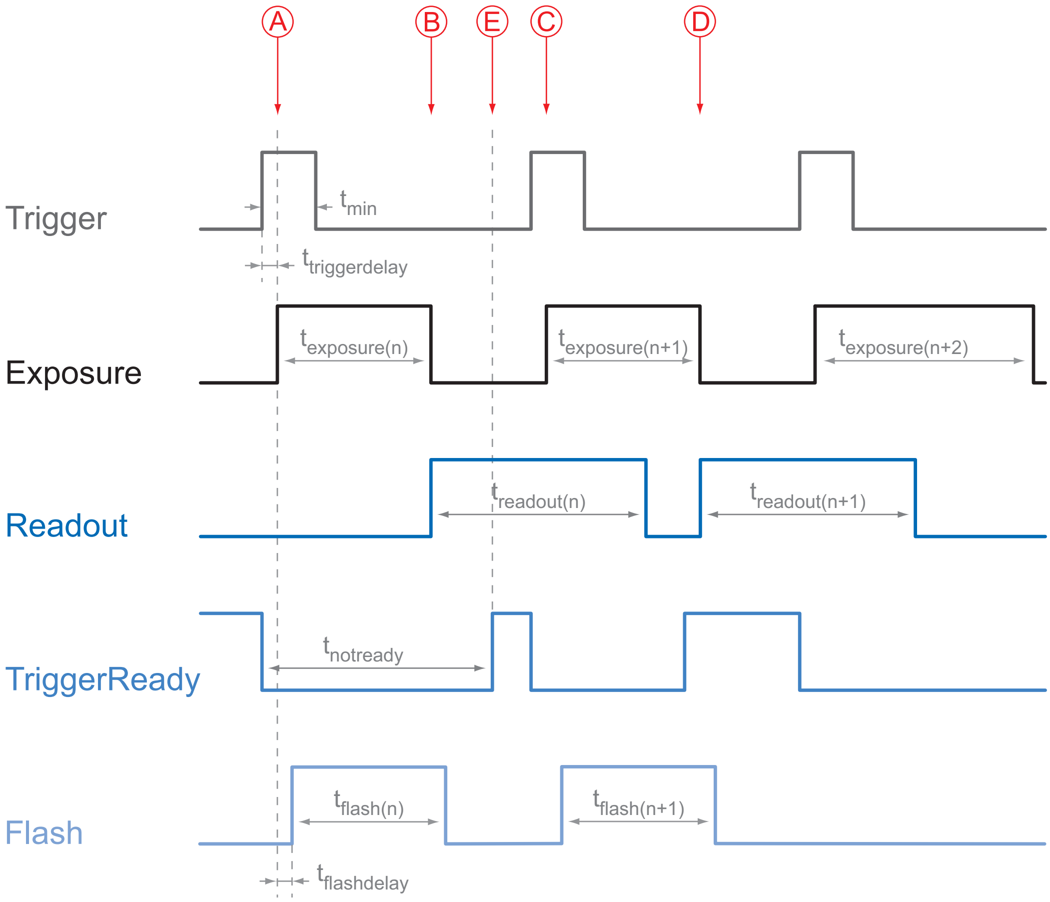
In case of identical exposure times, $t_{notready}$ remains the same from acquisition to acquisition.



2.4.3.2 Overlapped Operation: $t_{exposure(n+2)} > t_{exposure(n+1)}$

If the exposure time ($t_{exposure}$) is increased form the current acquisition to the next acquisition, the time the camera is unable to process occuring trigger signals ($t_{notready}$) is scaled down.

This can be simulated with the formulas mentioned above (no. 2 or 4, as is the case).



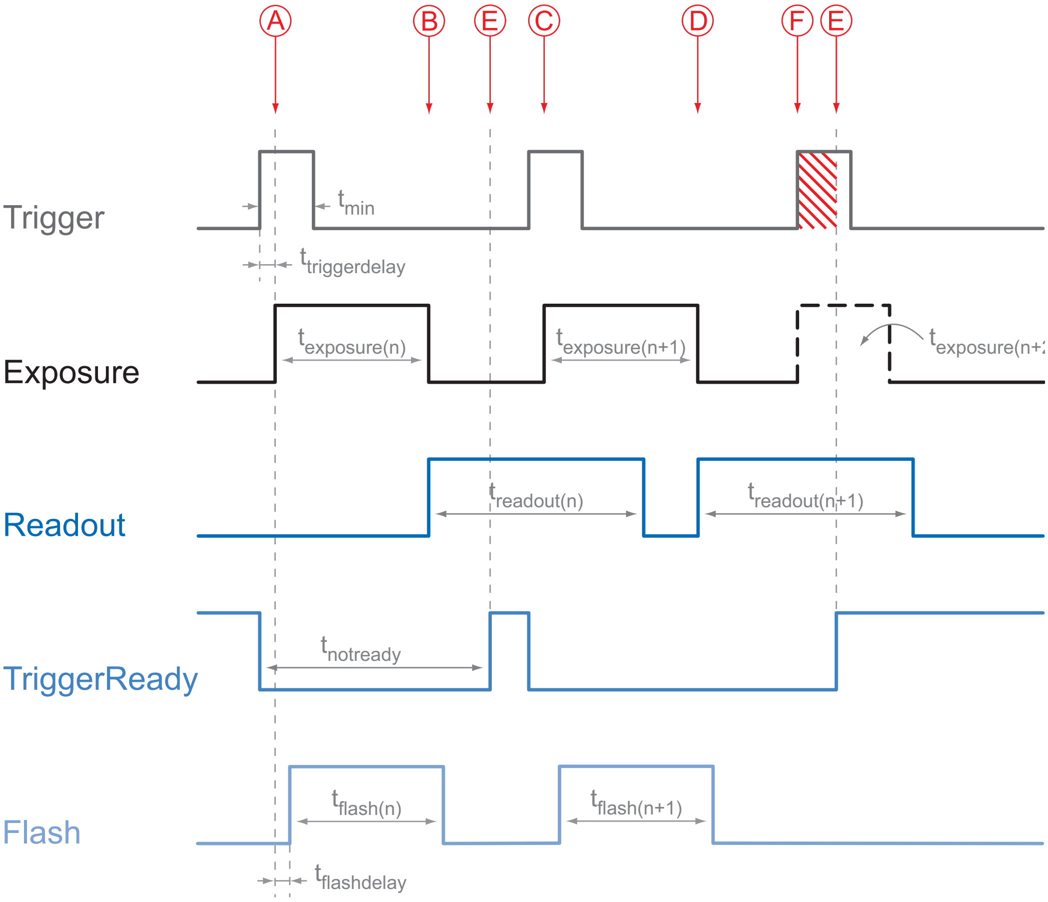
Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger

Image parameters:
Offset
Gain
Mode
Partial Scan

2.4.3.3 Overlapped Operation: $t_{exposure(n+2)} < t_{exposure(n+1)}$

If the exposure time ($t_{exposure}$) is decreased from the current acquisition to the next acquisition, the time the camera is unable to process occuring trigger signals ($t_{notready}$) is scaled up.

When decreasing the $t_{exposure}$ such, that $t_{notready}$ exceeds the pause between two incoming trigger signals, the camera is unable to process this trigger and the acquisition of the image will not start (the trigger will be skipped).



Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger
F - frame not started / trigger skipped

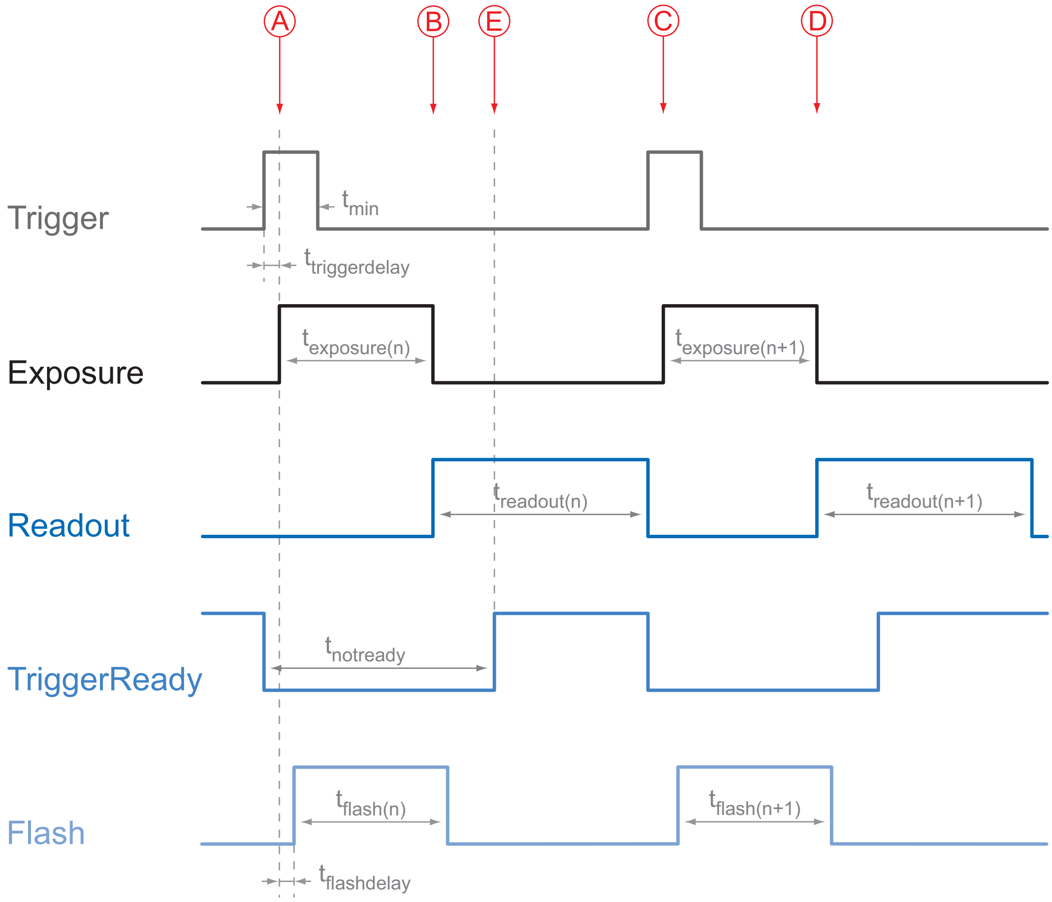
Image parameters:
Offset
Gain
Mode
Partial Scan

Notice

From a certain frequency of the trigger signal, skipping triggers is unavoidable. In general, this frequency depends on the combination of exposure and readout times.

2.4.3.4 Non-overlapped Operation

If the frequency of the trigger signal is selected for long enough, so that the image acquisitions ($t_{exposure}$ + $t_{readout}$) run successively, the camera operates non-overlapped.



Timings:
A - exposure time frame (n) effective
B - image parameters frame (n) effective
C - exposure time frame (n+1) effective
D - image parameters frame (n+1) effective
E - earliest possible trigger

Image parameters:
Offset
Gain
Mode
Partial Scan

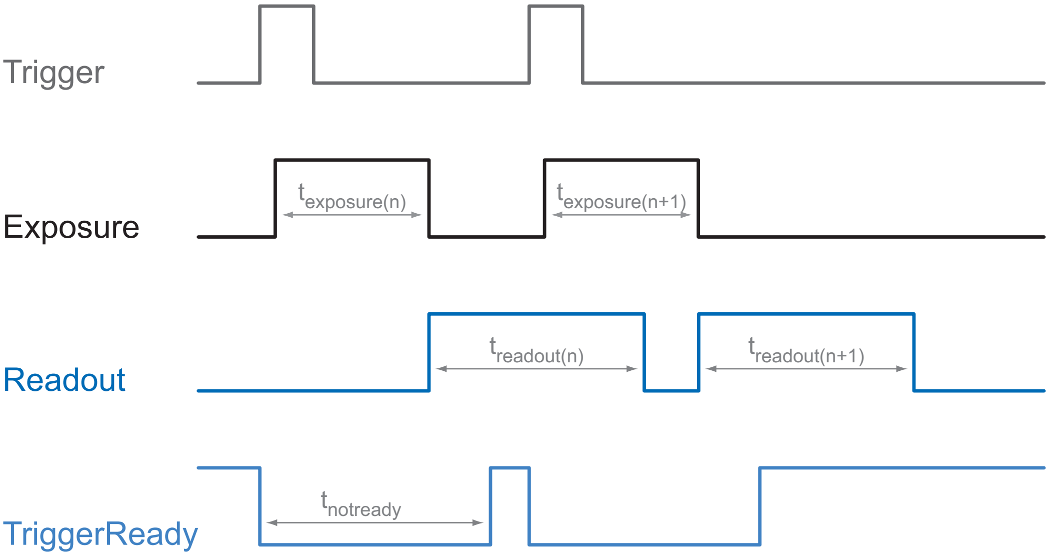
2.4.4 Advanced Timings for GigE Vision® Message Channel

The following charts show some timings for the event signaling by the asynchronous message channel. Vendor-specific events like "TriggerReady", "TriggerSkipped", "TriggerOverlapped" and "ReadoutActive" are explained.

Notice
For further information on the message channel mentioned above, please see section 5.6.

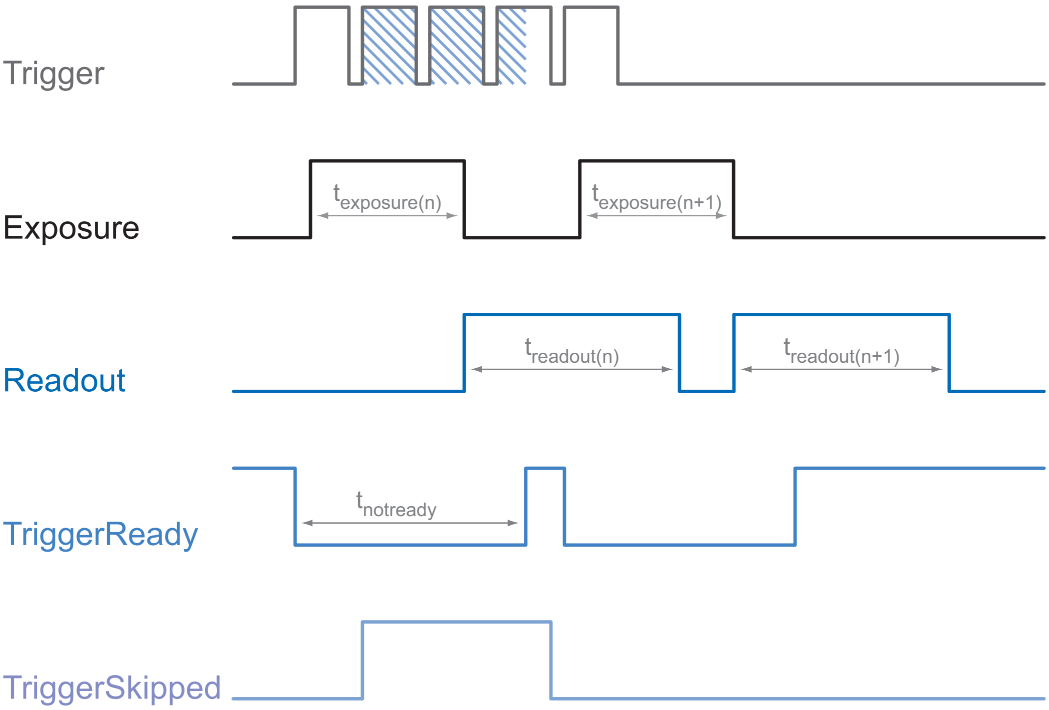
2.4.4.1 TriggerReady

This event signals whether the camera is able to process incoming trigger signals or not.



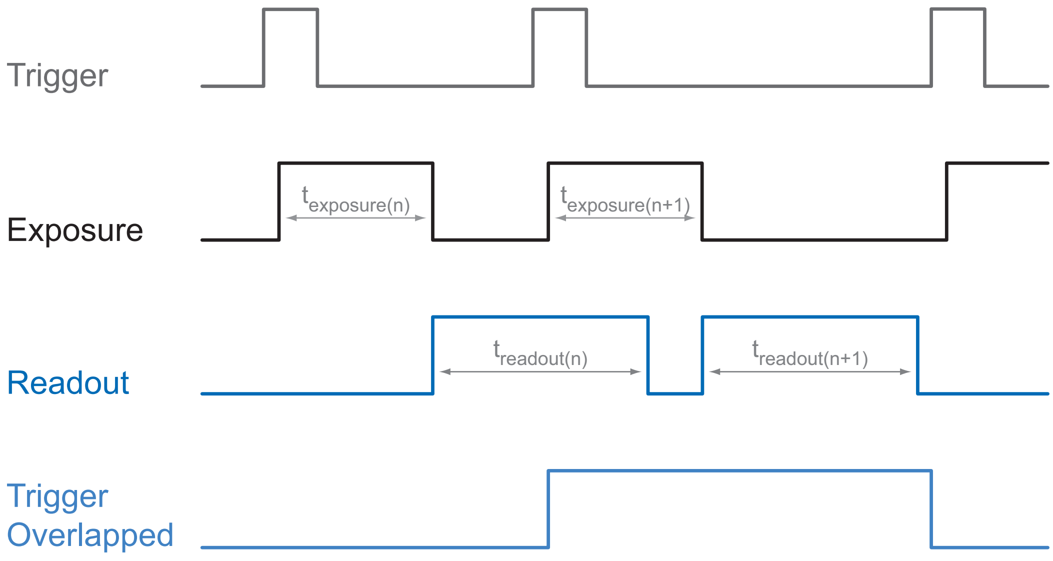
2.4.4.2 TriggerSkipped

If the camera is unable to process incoming trigger signals, which means the camera should be triggered within the interval $t_{notready}$, these triggers are skipped. On Baumer TXG cameras the user will be informed about this fact by means of the event "TriggerSkipped".



2.4.4.3 TriggerOverlapped

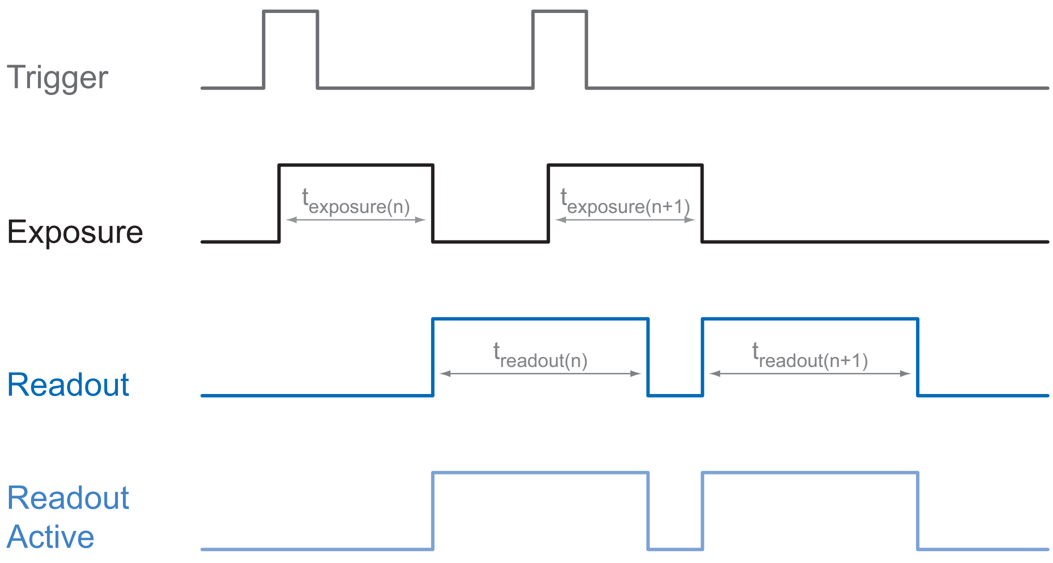
This signal is active, as long as the sensor is exposed and read out at the same time. which means the camera is operated overlapped.



Once a valid trigger signal occures not within a readout, the "TriggerOverlapped" signal changes to state low.

2.4.4.4 ReadoutActive

While the sensor is read out, the camera signals this by means of "ReadoutActive".



2.5 Environmental Requirements

2.5.1 Temperature and Humidity Range*)

Temperature	
Storage temperature	-10°C ... +70°C (+14°F ... +158°F)
Operating temperature*	+5°C ... +50°C (+41°F ... +122°F)
Housing temperature**)***)	max. +50°C (+122°F)

* For environmental temperatures ranging from (value A) to (value B), please pay attention to the max. housing temperature. The values are listed in the table below:

Camera Type	Value A	Value B
Monochrome		
TXG02	+26°C (+78,8°F)	+50°C (+122°F)
TXG03	+40°C (+104°F)	+50°C (+122°F)
TXG04	+39°C (+102.2°F)	+50°C (+122°F)
TXG06	+39°C (+102.2°F)	+50°C (+122°F)
TXG08	+40°C (+104°F)	+50°C (+122°F)
TXG12	+24°C (+75,2°F)	+50°C (+122°F)
TXG13	+38°C (+100.4°F)	+50°C (+122°F)
TXG14	+36°C (+96.8°F)	+50°C (+122°F)
TXG14f	+40°C (+104°F)	+50°C (+122°F)
TXG20	+38°C (+100.4°F)	+50°C (+122°F)
TXG50	+25°C (+77°F)	+50°C (+122°F)
TXG50-I7	+37°C (+98.6°F)	+50°C (+122°F)
Color		
TXG02c	+26°C (+78,8°F)	+50°C (+122°F)
TXG03c	+40°C (+104°F)	+50°C (+122°F)
TXG06c	+39°C (+102.2°F)	+50°C (+122°F)
TXG08c	+40°C (+104°F)	+50°C (+122°F)
TXG12c	+24°C (+75,2°F)	+50°C (+122°F)
TXG13c	+38°C (+100.4°F)	+50°C (+122°F)
TXG14c	+36°C (+96.8°F)	+50°C (+122°F)
TXG20c	+38°C (+100.4°F)	+50°C (+122°F)
TXG50c	+25°C (+77°F)	+50°C (+122°F)

Humidity	
Storage and Operating Humidity	10% ... 90% Non-condensing

◄ **Figure 26**
Temperature measurement points of Baumer TXG cameras: Standard camera and Camera with IP67 housing.

2.5.2 Heat Transmission

It is very important to provide adequate dissipation of heat, to ensure that the temperature does not reach or exceed +50°C (+122°F). As there are numerous possibilities for installation, Baumer do not specifiy a specific method for proper heat dissipation, but suggest the following principles:

- operate the cameras only in mounted condition
- mounting in combination with forced convection may provide proper heat dissipation

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*) Please refer to the respective data sheet.
**) Measured at temperature measurement point (T).
***) Housing temperature is limited by sensor specifications.

3. Software

3.1 Baumer-GAPI

Baumer-GAPI stands for Baumer “Generic Application Programming Interface”. With this API Baumer provides an interface for optimal integration and control of Baumer Gigabit Ethernet (GigE) and Baumer FireWire™ (IEEE1394) cameras.

This software interface allows changing to other camera models or interfaces. It also allows the simultaneous operation of Baumer cameras with Gigabit Ethernet and FireWire™ interfaces.

This GAPI supports both Windows® (XP and Vista) and Linux® (from Kernel 2.6.x) operating systems in 32 bit, as well as in 64 bit. It provides interfaces to several programming languages, such as C, C++ and the .NET™ Framework on Windows®, as well as Mono on Linux® operating systems, which offers the use of other languages, such as e.g. C# or VB.NET.

3.2 3rd Party Software

Strict compliance with the Gen<I>Cam™ standard allows Baumer to offer the use of 3rd Party Software for operation with cameras of the TXG family.

You can find a current listing of 3rd Party Software, which was tested successfully in combination with Baumer cameras, at http://www.baumergroup.com/cameras.

4. Camera Functionalities

4.1 Image Acquisition

4.1.1 Image Format

A digital camera usually delivers image data in at least one format - the native resolution of the sensor. Baumer cameras are able to provide several image formats (depending on the type of camera).

Compared with standard cameras, the image format on Baumer cameras not only includes resolution, but a set of predefined parameter.

These parameters are:
- Resolution (horizontal and vertical dimensions in pixels)
- Binning Mode(see chapter 4.1.6)
- HQ Mode (see chapter 4.1.7)

Camera Type	Full frame	Full frame HQ	Binning 2x2	Binning 2x2 HQ	Binning 1x2	Binning 1x2 HQ	Binning 2x1	Binning 2x1 HQ
Monochrome								
TXG02	■	■	■	■	■	■	■	■
TXG03	■	■	■	■	■	■	■	■
TXG04	■	□	■	□	■	□	■	□
TXG04h	■	■	□	□	□	□	□	□
TXG06	■	■	■	■	■	■	■	■
TXG08	■	■	■	■	■	■	■	■
TXG12	■	■	■	■	■	■	■	■
TXG13	■	■	■	■	■	■	■	■
TXG14	■	■	■	■	■	■	■	■
TXG14f	■	■	■	■	■	■	■	■
TXG20	■	■	■	■	■	■	■	■
TXG50	■	■	■	■	■	■	■	■
Color								
TXG02c	■	■	□	□	□	□	□	□
TXG03c	■	■	□	□	□	□	□	□
TXG06c	■	■	□	□	□	□	□	□
TXG08c	■	■	□	□	□	□	□	□
TXG12c	■	■	□	□	□	□	□	□
TXG13c	■	■	□	□	□	□	□	□
TXG14c	■	■	□	□	□	□	□	□
TXG20c	■	■	□	□	□	□	□	□
TXG50c	■	■	□	□	□	□	□	□

4.1.2 Pixel Format

On Baumer digital cameras the pixel format depends on the selected image format.

4.1.2.1 Definitions

RAW: Raw data format. Here the data are stored without processing.

Bayer: Raw data format of color sensors.
Color filters are placed on these sensors in a checkerboard pattern, generally in a 50% green, 25% red and 25% blue array.

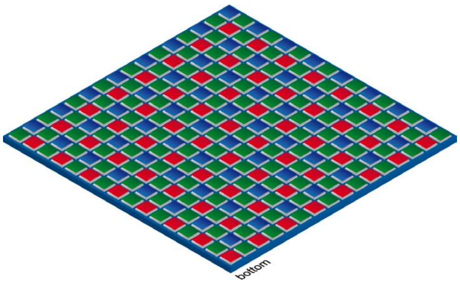


Figure 27 ▶
Sensor with Bayer Pattern

Mono: Monochrome. The color range of mono images consists of shades of a single color. In general, shades of gray or black-and-white are synonyms for monochrome.

RGB: Color model, in which all detectable colors are defined by three coordinates, Red, Green and Blue.

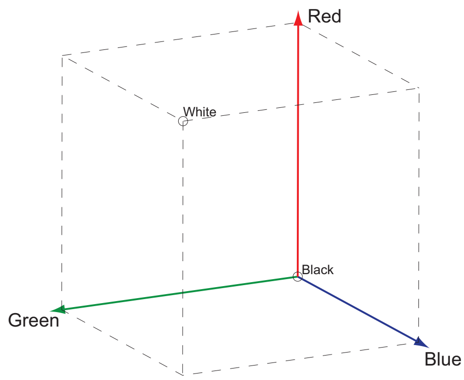


Figure 28 ▶
RBG color space displayed as color tube.

The three coordinates are displayed within the buffer in the order R, G, B.

BGR: Here the color alignment mirrors RGB.

YUV: Color model, which is used in the PAL TV standard and in image compression. In YUV, a high bandwidth luminance signal (Y: luma information) is transmitted together with two color difference signals with low bandwidth (U and V: chroma information). Thereby U represents the difference between blue and luminance (U = B - Y), V is the difference between red and luminance (V = R - Y). The third color, green, does not need to be transmitted, its value can be calculated from the other three values.

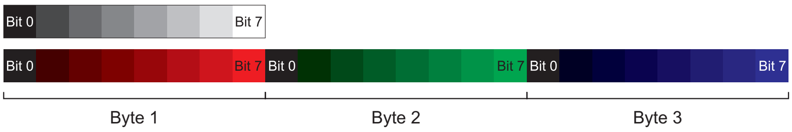
- YUV 4:4:4 Here each of the three components has the same sample rate. Therefore there is no subsampling here.
- YUV 4:2:2 The chroma components are sampled at half the sample rate. This reduces the necessary bandwidth to two-thirds (in relation to 4:4:4) and causes no, or low visual differences.
- YUV 4:1:1 Here the chroma components are sampled at a quater of the sample rate.This decreases the necessary bandwith by half (in relation to 4:4:4).

Pixel depth: In general, pixel depth defines the number of possible different values for each color channel. Mostly this will be 8 bit, which means 2^8 different "colors".

For RGB or BGR these 8 bits per channel equal 24 bits overall.

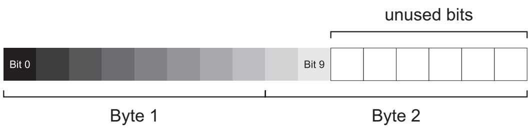
Two bytes are needed for transmitting more than 8 bits per pixel - even if the second byte is not completely filled with data. In order to save bandwidth, the packed formats were introduced to Baumer TXG cameras. In this formats, the unused bits of one pixel are filled with data from the next pixel.

8 bit:



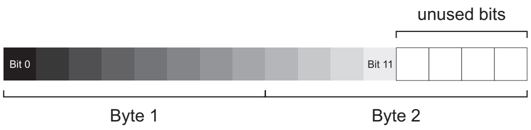
◄ **Figure 29**
Bit string of Mono 8 bit and RGB 8 bit.

10 bit:



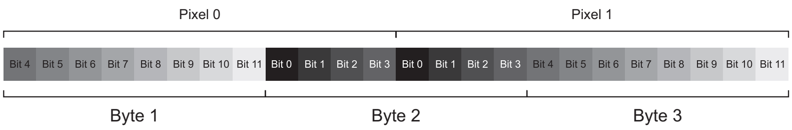
◄ **Figure 30**
Spreading of Mono 10 bit over 2 bytes.

12 bit:



◄ **Figure 33**
Spreading of Mono 12 bit over two bytes.

Packed:



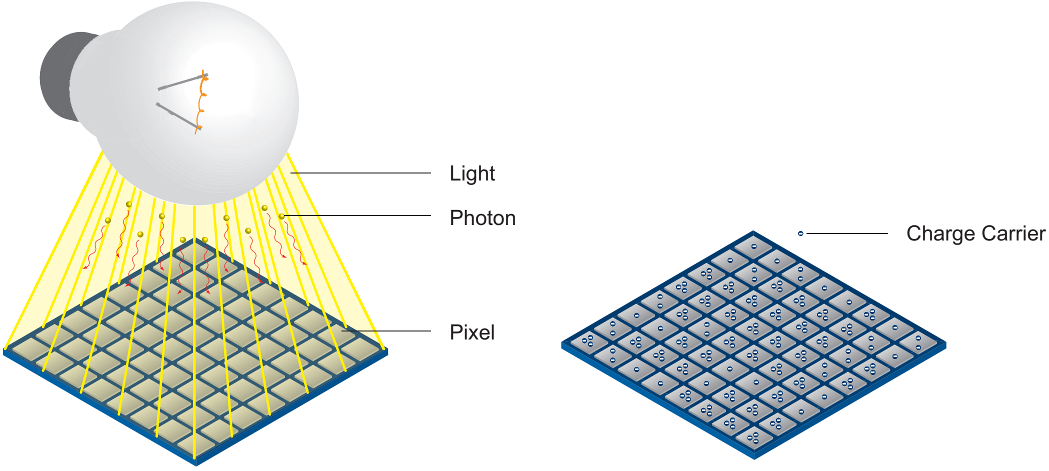
◄ **Figure 32**
Spreading of two pixels in Mono 12 bit over three bytes (packed mode).

4.1.2.2 Pixel Formats on Baumer TXG Cameras

Camera Type	Mono 8	Mono 10	Mono 10 Packed	Mono 12	Mono 12 Packed	Bayer RG 8	Bayer RG 10	Bayer RG 12	RGB 8 Packed	BGR 8 Packed	YUV 444 Packed	YUV 422 Packed	YUV 411 Packed
Monochrome													
TXG02	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG03	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG04	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG04h	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG06	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG08	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG12	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG13	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG14	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG14f	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG20	■	□	□	■	■	□	□	□	□	□	□	□	□
TXG50	■	□	□	■	■	□	□	□	□	□	□	□	□
Color													
TXG02c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG03c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG04c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG06c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG08c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG12c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG13c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG14c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG20c	■	□	□	□	□	■	□	■	■	■	■	■	■
TXG50c	■	□	□	□	□	■	□	■	■	■	■	■	■

4.1.3 Exposure Time

On exposure of the sensor, the inclination of photons produces a charge separation on the semiconductors of the pixels. This results in a voltage difference, which is used for signal extraction.



◄ **Figure 33**
Incidence of light causes charge separation on the semiconductors of the sensor.

The signal strength is influenced by the incoming amount of photons. It can be increased by increasing the exposure time ($t_{exposure}$).

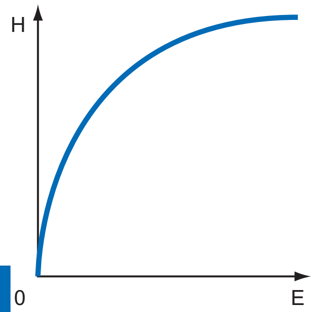
On Baumer TXG cameras, the exposure time can be set within the following ranges (step size 1µsec):

Camera Type	$t_{exposure}$ min	$t_{exposure}$ max
Monochrome		
TXG02	4 µsec	60 sec
TXG03	4 µsec	60 sec
TXG04	4 µsec	60 sec
TXG04h	15 µsec	2 sec
TXG06	4 µsec	60 sec
TXG08	4 µsec	60 sec
TXG12	4 µsec	60 sec
TXG13	4 µsec	60 sec
TXG14	4 µsec	60 sec
TXG14f	4 µsec	60 sec
TXG20	4 µsec	60 sec
TXG50	4 µsec	2 sec
Color		
TXG02c	4 µsec	60 sec
TXG03c	4 µsec	60 sec
TXG04c	4 µsec	60 sec
TXG06c	4 µsec	60 sec
TXG08c	4 µsec	60 sec
TXG12c	4 µsec	60 sec
TXG13c	4 µsec	60 sec
TXG14c	4 µsec	60 sec
TXG20c	4 µsec	60 sec
TXG50c	4 µsec	2 sec

4.1.4 Look-Up-Table

The Look-Up-Table (LUT) is employed on Baumer monochrome cameras. It contains 2^{12} (4096) values for the available levels of gray. These values can be adjusted by the user.

In this example the LUT is used to overwrite levels of gray which are not of interest or in the case of overdrive.



▲ **Figure 34**
Non-linear perception of the human eye.
H - Perception of brightness
E - Energy of light

4.1.5 Gamma Correction

With this feature, Baumer TXG cameras offer the possibility of compensating nonlinearity in the perception of light by the human eye.

For this correction, the corrected pixel intensity (Y') is calculated from the original intensity of the sensor's pixel ($Y_{original}$) and correction factor γ using the following formula (in over-simplified version):

$$Y' = Y_{original}^{\gamma}$$

On Baumer TXG cameras the correction factor γ is adjustable from 0.001 to 2.

The values of the calculated intensities are entered into the Look-Up-Table (see 4.1.4.). Thereby previously existing values within the LUT will be overwritten.

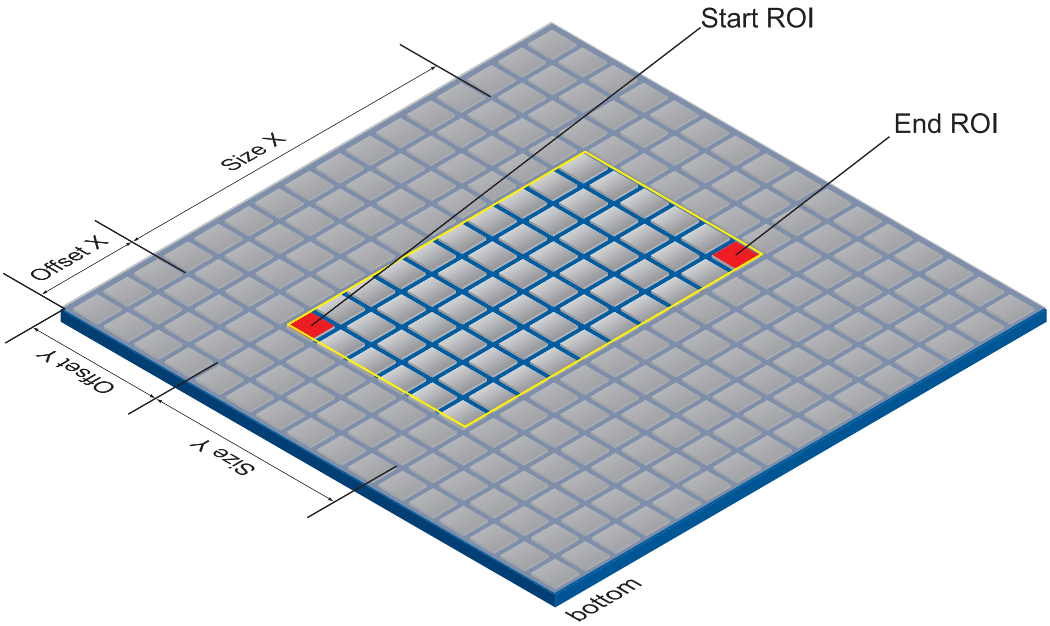
Notice
If the LUT feature is disabled on the software side, the gamma correction feature also is disabled.

4.1.6 Region of Interest (ROI)

With the "Region of Interest" function it is possible to predefine a so-called Region of Interest (ROI) or Partial Scan. This ROI is an area of pixels of the sensor. On image acquisition, only the information of these pixels is sent to the PC. Therefore all the lines of the sensor need not be read out, which decreases the readout time ($t_{readout}$). This increases the frame rate.

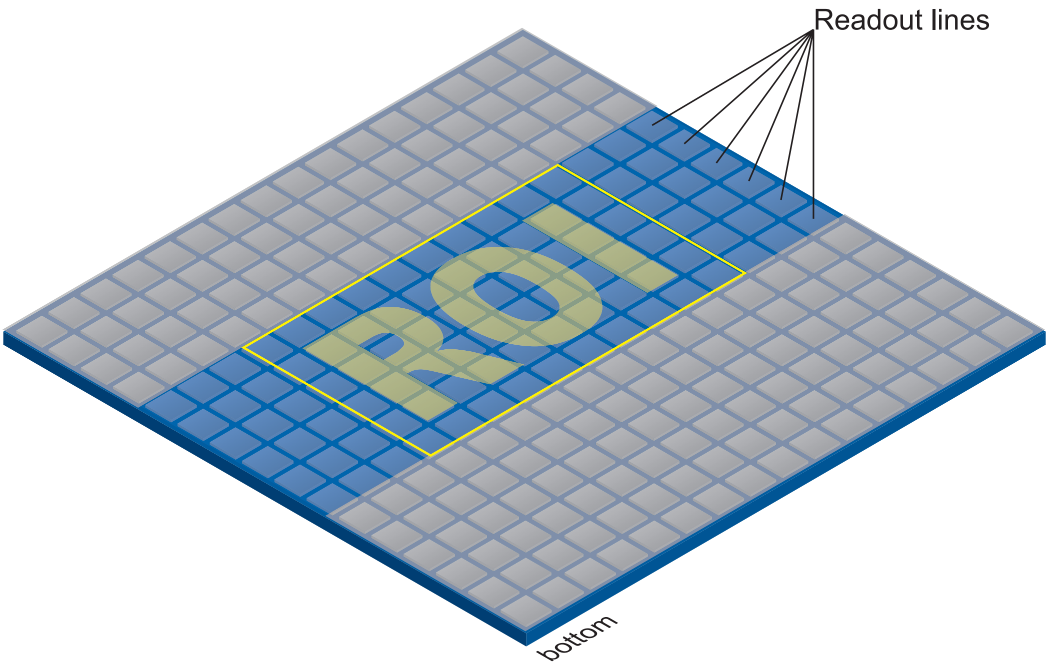
This function is employed, when only a region of the field of view is of interest. It is coupled to a reduction in resolution.

The ROI is specified by four values:
- Offset X - x-coordinate of the first relevant pixel
- Offset Y - y-coordinate of the first relevant pixel
- Size X - horizontal size of the ROI
- Size Y - vertical size of the ROI



◄ **Figure 35**
Partial Scan:
Parameters of the ROI.

In the illustration below, readout time would be decreased to 40%, compared with a full frame readout.



◄ **Figure 36**
Decrease in readout time by using partial scan.

4.1.7 Binning

On digital cameras, you can find several operations for progressing sensitivity. One of them is the so-called "Binning". Here, the charge carriers of neighboring pixels are aggregated. Thus, the progression is greatly increased by the amount of binned pixels. By using this operation, the progression in sensitivity is coupled to a reduction in resolution.

Baumer cameras support three types of Binning - vertical, horizontal and bidirectional.

In unidirectional binning, vertically or horizontally neighboring pixels are aggregated and reported to the software as one single "superpixel".

In bidirectional binning, a square of neighboring pixels is aggregated.

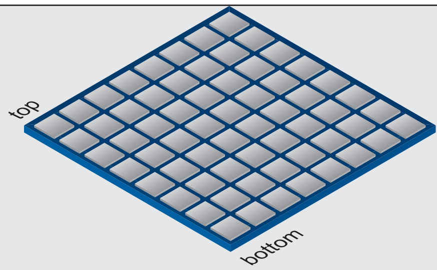
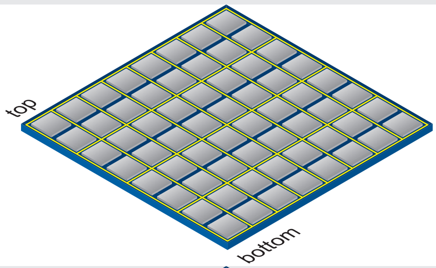
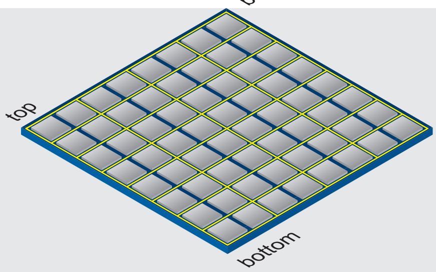
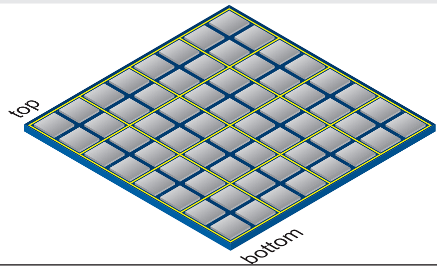
Binning	Illustration	Example
without		
1x2		
2x1		
2x2		

Figure 37 ▶
Full frame image, no binning of pixels.

Figure 38 ▶
Vertical binning causes a vertically compressed image with doubled brightness.

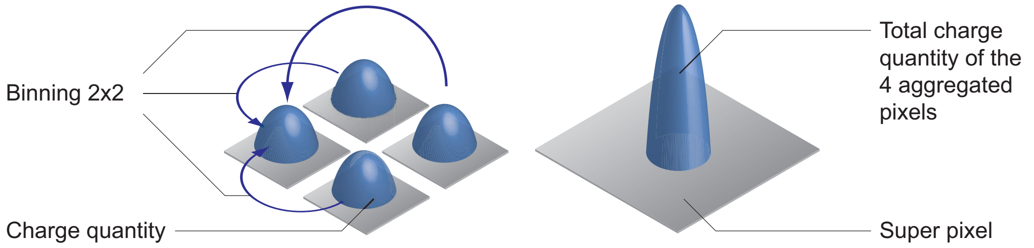
Figure 39 ▶
Horizontal binning causes a horizontally compressed image with doubled brightness.

Figure 40 ▶
Bidirectional binning causes both a horizontally and vertically compressed image with quadruple brightness.

4.1.8 Brightness Correction (Binning Correction)

The aggregation of charge carriers may cause an overload. To prevent this, binning correction was introduced. Here, three binning modes need to be considered separately:

Binninig	Realization
1x2	1x2 binning is performed within the sensor, binning correction also takes place here. A possible overload is prevented by halving the exposure time.
2x1	2x1 binning takes place within the FPGA of the camera. The binning correction is realized by aggregating the charge quantities, and then halving this sum.
2x2	2x2 binning is a combination of the above versions.



◄ **Figure 41**
Aggregation of charge carriers from four pixels in bidirectional binning.

4.1.9 Fast Mode

The Fast Mode is employed in 90% of all cases.
Here you can use the full frame rate of the camera. Short readout times cause a decrease in the smear effect.

4.1.10 HQ Mode

In HQ Mode the pixel clock of the sensor is mottled. This leads to longer readout times and enhances the signal-to-noise ratio (SNR). Hereby the image quality is increased.

4.2 Color Processing

Baumer color cameras are balanced to a color temperature of 5000 K.

Oversimplified, color processing is realized by 4 modules.

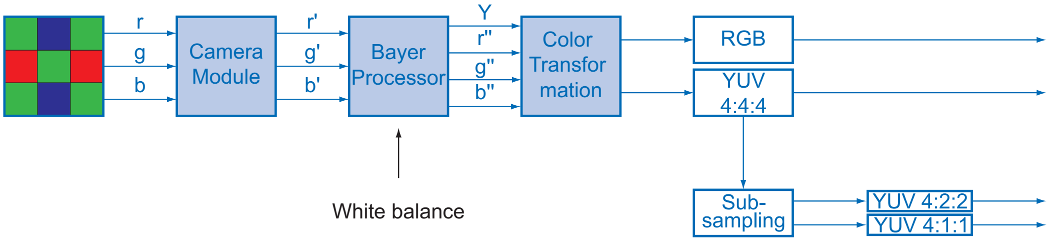


Figure 42 ▶ Color processing modules of Baumer color cameras.

The color signals r (red), g (green) and b (blue) of the sensor are amplified in total and digitized within the camera module.

Within the Bayer processor, the raw signals r', g' and b' are amplified by using of independent factors for each color channel. Then the missing color values are interpolated, which results in new color values (r'', g'', b''). The luminance signal Y is also generated.

The next step is the color transformation. Here the previously generated color signals r'', g'' and b'' are converted to the chroma signals U and V, which conform to the standard. Afterwards theses signals are transformed into the desired output format. Thereby the following steps are processed simultaneously:

- Transformation to color space RGB or YUV
- External color adjustment
- Color adjustment as physical balance of the spectral sensitivities

In order to reduce the data rate of YUV signals, a subsampling of the chroma signals can be carried out. Here the following items can be customized to the desired output format:

- Order of data output
- Subsampling of the chroma components to YUV 4:2:2 or YUV 4:1:1
- Limitation of the data rate to 8 bits

4.3 Color Adjustment – White Balance

This feature is available on all color cameras of the Baumer TXG series and takes place within the Bayer processor.

White balance means independent adjustment of the three color channels, red, green and blue by employing of a correction factor for each channel.

4.3.1 User-specific Color Adjustment

The user-specific color adjustment in Baumer color cameras facilitates adjustment of the correction factors for each color gain. This way, the user is able to adjust the amplification of each color channel exactly to his needs. The correction factors for the color gains range from 1 to 4.

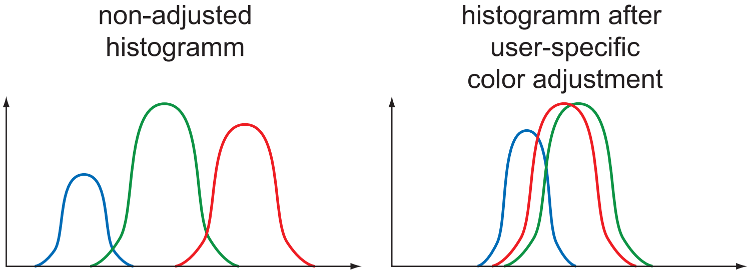
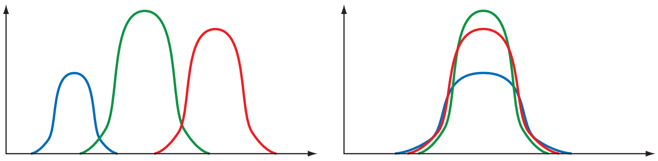


Figure 43 ▶ Examples of histogramms for a non-adjusted image and for an image after user-specific white balance..

4.3.2 One Push White Balance

Here, the three color spectrums are balanced to a single white point. The correction factors of the color gains are determined by the camera (one time).



◄ **Figure 44**
Examples of histogramms for a non-adjusted image and for an image after "one push" white balance.

4.4 Analog Controls

4.4.1 Offset / Black Level

On Baumer cameras, the offset (or black level) is adjustable from 0 to 16 LSB (relating to 8 bit).

Camera Type	Step Size 1 LSB Relating to
Monochrome	
TXG02	12 bit
TXG03	12 bit
TXG04	14 bit
TXG04h	14 bit
TXG06	12 bit
TXG08	12 bit
TXG12	14 bit
TXG13	12 bit
TXG14	12 bit
TXG14f	14 bit
TXG20	12 bit
TXG50	14 bit
Color	
TXG02c	14 bit
TXG03c	12 bit
TXG04c	14 bit
TXG06c	12 bit
TXG08c	12 bit
TXG12c	14 bit
TXG13c	12 bit
TXG14c	12 bit
TXG20c	12 bit
TXG50c	14 bit

4.4.2 Gain

In industrial environments motion blur is unacceptable. Due to this fact exposure times are limited. However, this causes low output signals from the camera and results in dark images. To solve this issue, the signals can be amplified by a user-defined gain factor within the camera. This gain factor is adjustable from 1 to 10.

Notice
Increasing the gain factor causes an increase of image noise.

4.5 Pixel Correction

4.5.1 General information

A certain probability for abnormal pixels - the so-called defect pixels - applies to the sensors of all manufacturers. The charge quantity on these pixels is not linear-dependent on the exposure time.

The occurrence of these defect pixels is unavoidable and intrinsic to the manufacturing and aging process of the sensors.

The operation of the camera is not affected by these pixels. They only appear as brighter (warm pixel) or darker (cold pixel) spot in the recorded image.

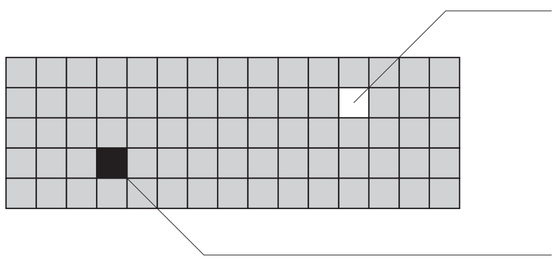


Figure 45 ►
Distinction of "hot" and "cold" pixels within the recorded image.

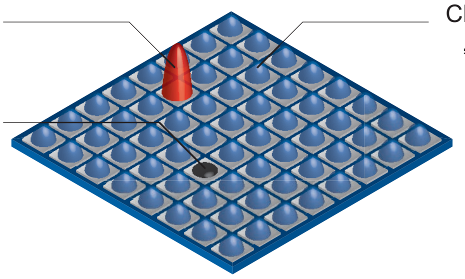
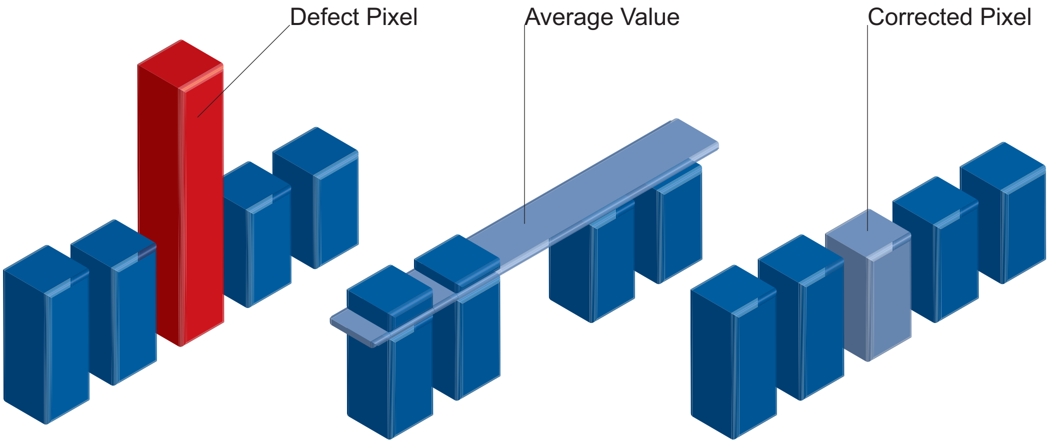


Figure 46 ►v
Charge quantity of "hot" and "cold" pixels compared with "normal" pixels.

4.5.2 Correction Algorithm

On monochrome cameras of the Baumer TXG series, the problem of defect pixels is solved as follows:

- Possible defect pixels are identified during the production process of the camera.
- The coordinates of these pixels are stored in the factory settings of the camera (see 4.5.3. Defectpixellist).
- Once the sensor readout is completed, correction takes place:
  - Before any other processing, the values of the two neighboring pixels on the left and the right side of the defect pixel, will be read out
  - Then the average value of these 4 pixels is determined
  - Finally, the value of the defect pixel is substituted by the previously determined average value



◄ **Figure 47**
Schematic diagram of the Baumer pixel correction.

4.5.3 Defectpixellist

As stated previously, this list is determined within the production process of Baumer cameras and stored in the factory settings (see 4.8.1.).

Additional hot or cold pixels can develop during the lifecycle of a camera. In this case Baumer offers the possibility of adding their coordinates to the defectpixellist. The user can determine the coordinates*) of the affected pixels and add them to the list. Once the defect pixel list is stored in a user set (see 4.8.), pixel correction is executed for all coordinates on the defectpixellist.

*) Position in relation to Full Frame Format.

4.6 Process Interface

4.6.1 Digital IOs

Baumer standard cameras are equipped each with on digital input and one digital output.

Additional digital in- and outputs (IOs) are offered by the following cameras of the Baumer TXG series:

Monochrome Cameras	Color Cameras
TXG03m3	TXG03cm3
TXG13m3	
TXG14m3	
TXG20m3	TXG20cm3
TXG50m3	

4.6.1.1 User Definable Inputs

The wiring of these input connectors is left to the user.

Sole exception is the compliance with predetermined high and low levels (0 .. 4,5V low, 11 .. 30V high).

The defined signals will have no direct effect, but can be analyzed and processed on the software side and used for controlling the camera.

The employment of a so called "IO matrix" offers the possibility of selecting the signal and the state to be processed.

On the software side the input signals are named "Trigger", "Input 1" and "Input 2".

Due to the fact, that the TXG models standard and m3 have a different number of in- and outputs, there are two kinds of IO matrixes for the input side the output side:

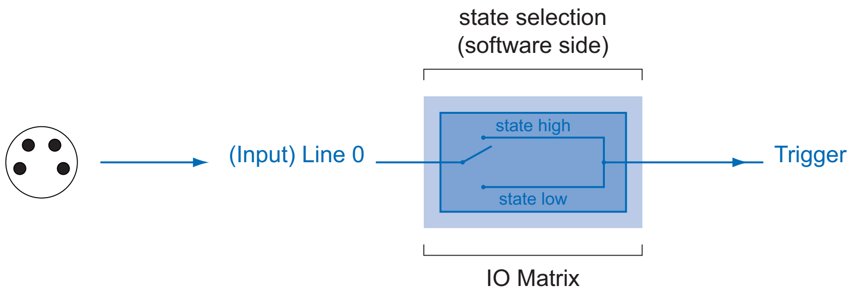
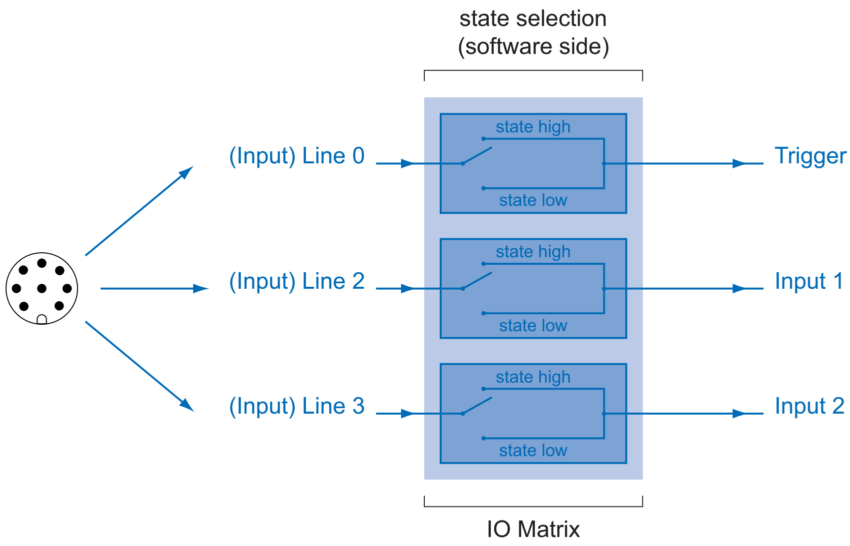


Figure 48 ▶
IO matrix of the Baumer TXG standard cameras on input side.



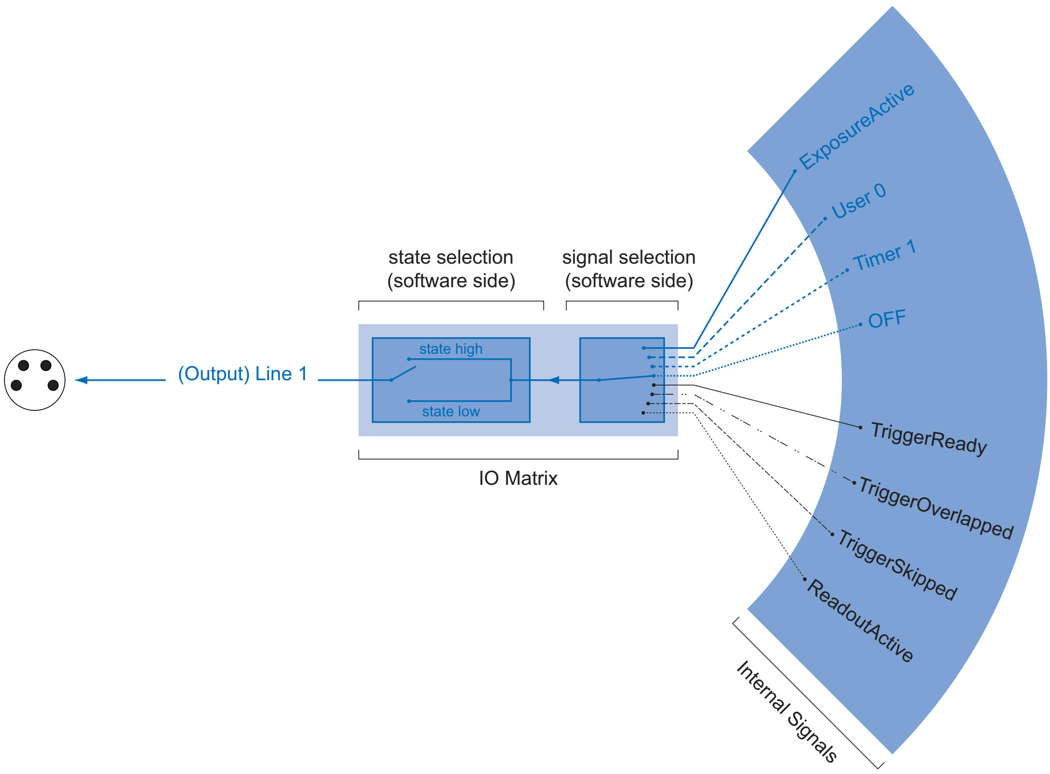
◄ **Figure 49**
IO matrix of the Baumer TXGm3 on input side.

4.6.1.2 Configurable Outputs

With this feature, Baumer offers the possibility of wiring the output connectors to internal signals, which are controlled on the software side.

Hereby on TXG standard cameras, the output connector can be wired to one of provided internal signal "ExposureActive" (Flash), "User0", "TriggerReady", "TriggerOverlapped", "TriggerSkipped", "ReadoutActive" and "Timer1". Beside this, the output can be disabled.

On TXGm3 cameras, the possible internal signals are "ExposureActive" (Flash), "User 0", "User 1", "TriggerReady", "TriggerOverlapped", "TriggerSkipped" and "ReadoutActive". Also here the outputs can be disabled.



◄ **Figure 50**
IO matrix of the Baumer TXG standard camera on output side.

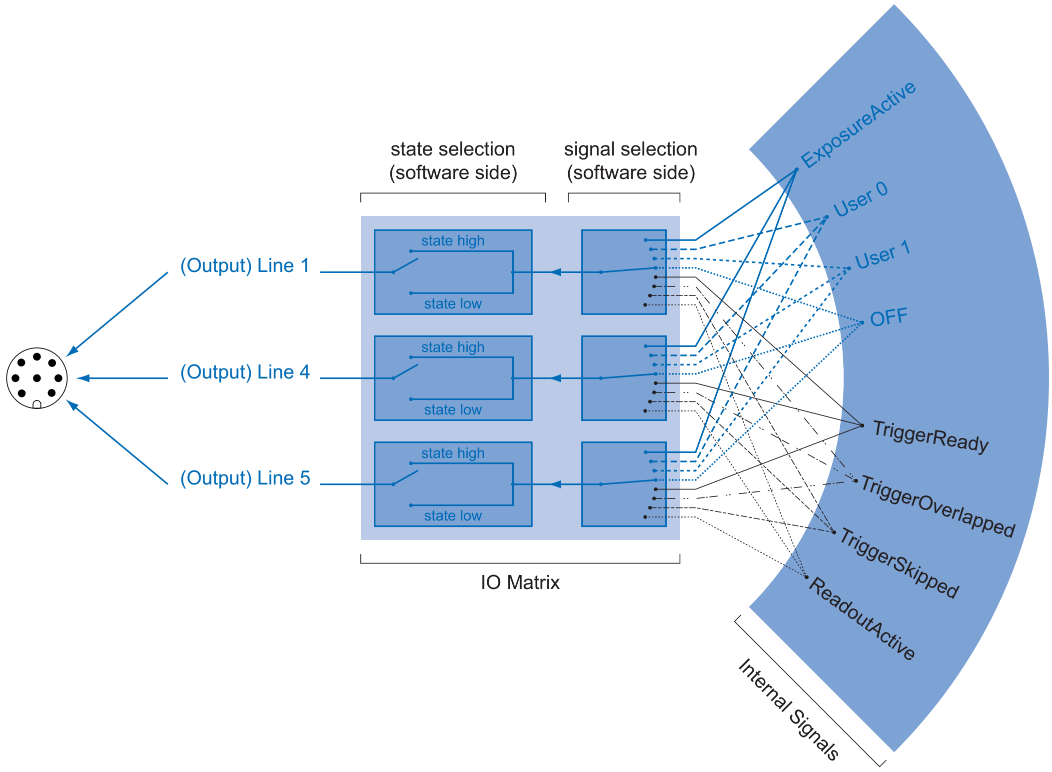
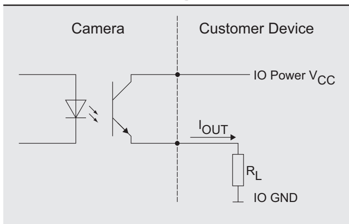
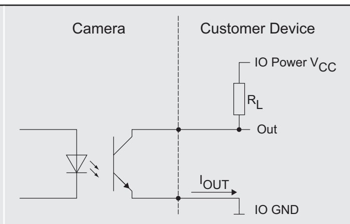
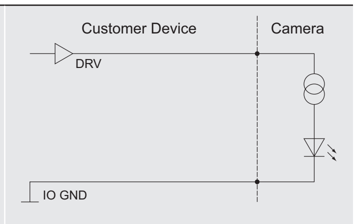


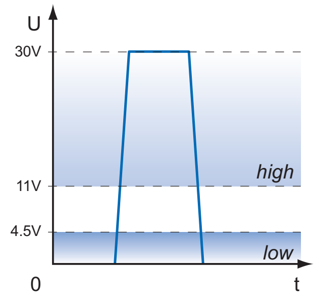
Figure 51 ▶
IO matrix of the Baumer TXGm3 on output side.

4.6.2 IO Circuits

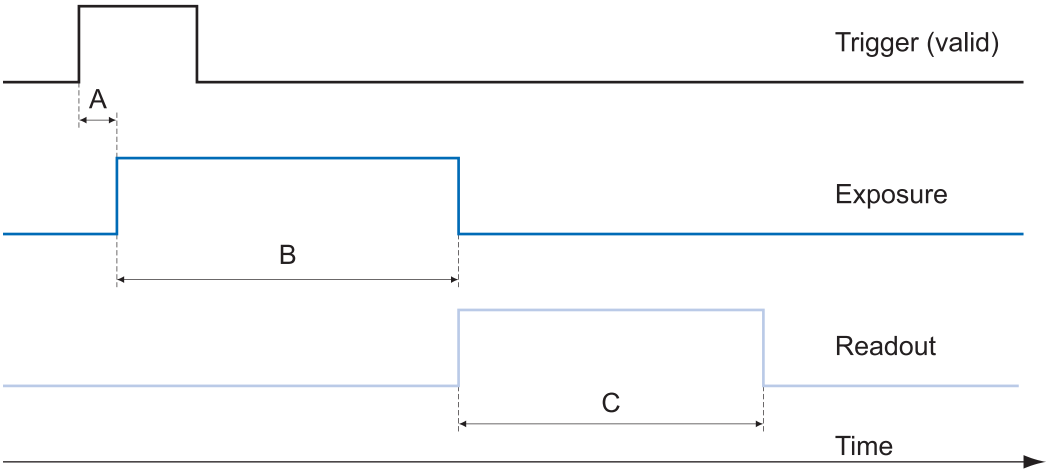
Output high active	Output low active	Input
		

4.6.3 Trigger

Trigger signals are used to synchronize the camera exposure and a machine cycle or, in case of a software trigger, to take images at predefined time intervals.



▲ **Figure 52**
Trigger signal, valid for Baumer cameras.

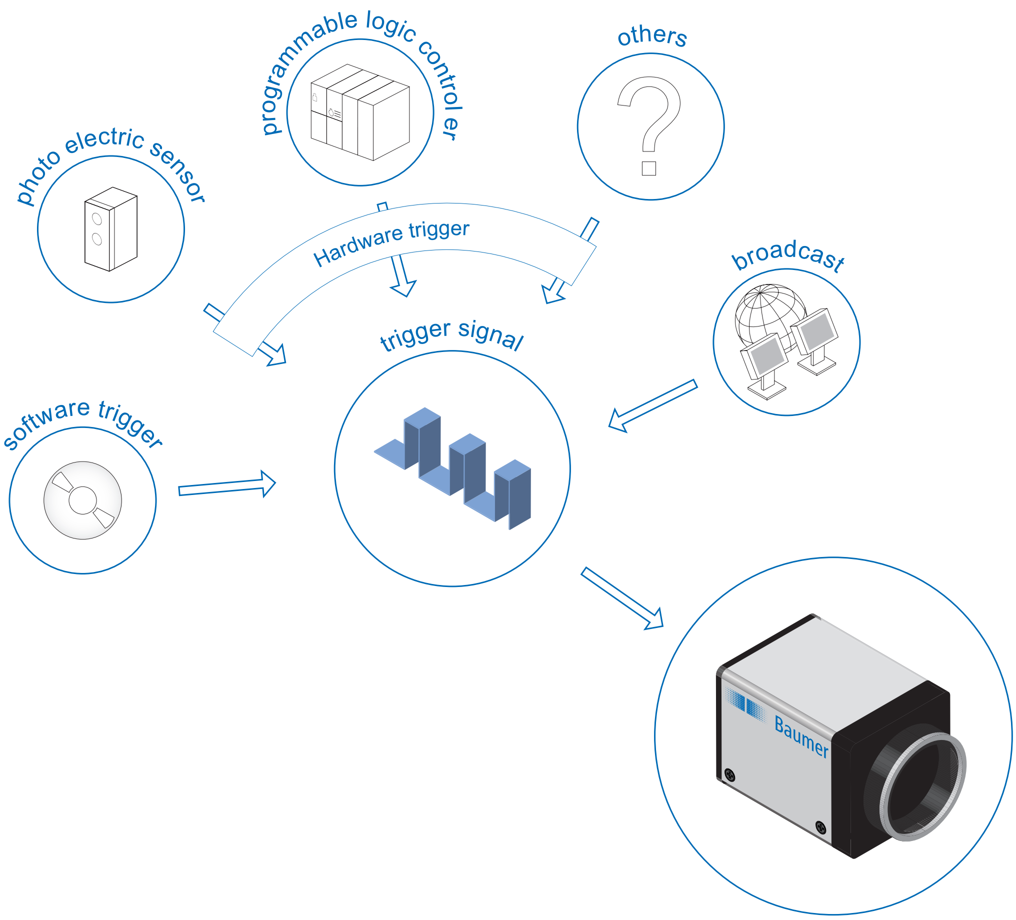


◄ **Figure 53**
Camera in trigger mode:
A - Trigger delay
B - Exposure time
C - Readout time

Different trigger sources can be used here.

4.6.4 Trigger Source

Trigger Delay:
The trigger delay is a flexible user-defined delay between the given trigger impulse and the image capture. The delay time can be set between 0.0 µsec and 2.0 sec with a stepsize of 1 µsec. In the case of multiple triggers during the delay the triggers will be stored and delayed, too. The buffer is able to store up to 512 trigger signals during the delay. Your benefits: ▪ *No need for a perfect alignment of an external trigger sensor* ▪ *Different objects can be captured without hardware changes*



◄ **Figure 54**
Examples of possible trigger sources.

Each trigger source has to be activated separately. When the trigger mode is activated, the hardware trigger is activated by default.

4.6.5 Debouncer

The basic idea behind this feature was to seperate interfering signals (short peaks) from valid square wave signals, which can be important in industrial environments. Debouncing means that invalid signals are filtered out, and signals lasting longer than a user-defined testing time $t_{DebounceHigh}$ will be recognized, and routed to the camera to induce a trigger.

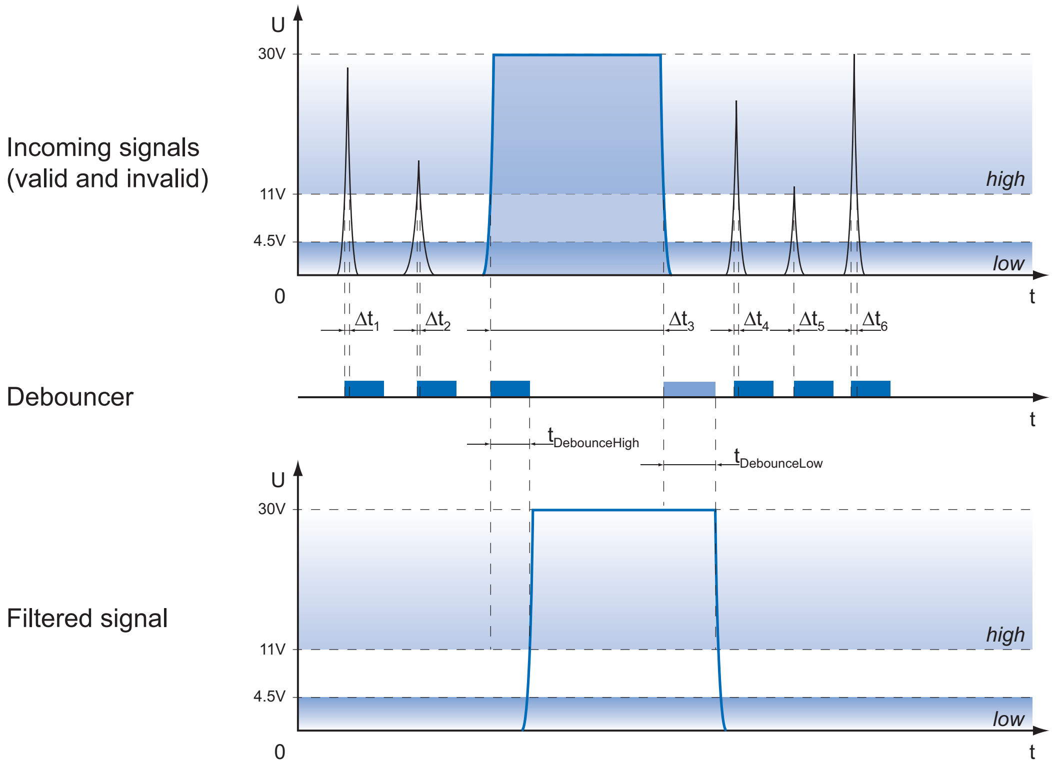
In order to detect the end of a valid signal and filter out possible jitters within the signal, a second testing time $t_{DebounceLow}$ was introduced. This timing is also adjustable by the user. If the signal value falls to state low and does not rise within $t_{DebounceLow}$, this is recognized as end of the signal.

The debouncing times $t_{DebounceHigh}$ and $t_{DebounceLow}$ are adjustable from 0 to 5 msec in steps of 1 µsec.

This feature is disabled by default.

Debouncer:

Please note that the edges of valid trigger signals are shifted by $t_{DebounceHigh}$ and $t_{DebounceLow}$!
Depending on these two timings, the trigger signal might be temporally stretched or compressed.



Δt_x high time of the signal
$t_{DebounceHigh}$ user defined debouncer delay for state high
$t_{DebounceLow}$ user defined debouncer delay for state low

Figure 55 ▶
Principle of the Baumer debouncer.

4.6.6 Flash Signal

This signal is managed by exposure of the sensor.

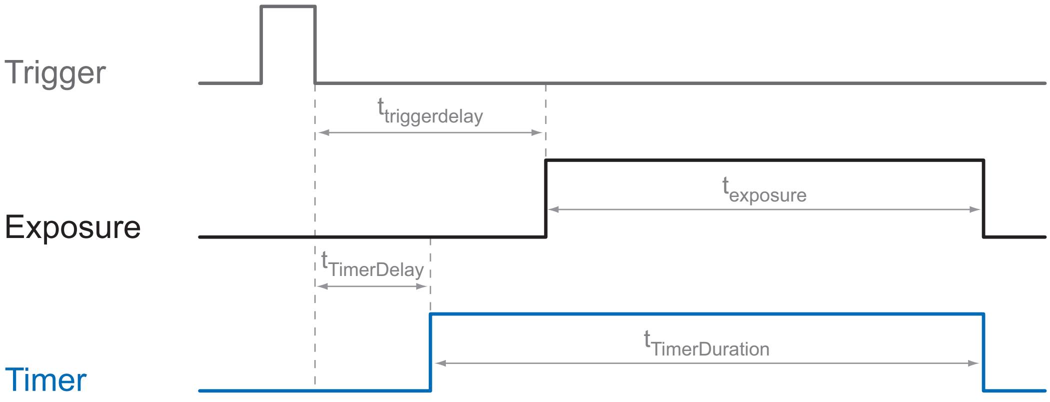
Furthermore, the falling edge of the flash output signal can be used to trigger a movement of the inspected objects. Due to this fact, the span time used for the sensor readout $t_{readout}$ can be used optimally in industrial environments.

4.6.7 Timers

Timers were introduced for advanced control of internal camera signals.

For example the employment of a timer allows you to control the flash signal in that way, that the illumination does not start synchronized to the sensor exposure but a predefined interval earlier.

On Baumer TXG cameras the timer configuration includes four components:



◄ **Figure 56**
Poss ble Timer configuration on a Baumer TXG.

Component	Description
TimerTriggerSource	This feature provides a source selection for each timer.
TimerTriggerActivation	This feature selects that part of the trigger signal (edges or states) that activates the timer.
TimerDelay	This feature represents the interval between incoming trigger signal and the start of the timer.
TimerDuration	By this feature the activation time of the timer is adjustable.

4.6.7.1 Flash Delay

As previously stated, the Timer feature can be used to start the connected illumination earlier than the sensor exposure.

This implies a timer configuration as follows:
- The flash output needs to be wired to the selected internal Timer signal.
- Trigger source and trigger activation for the Timer need to be the same as for the sensor exposure.
- The TimerDelay feature ($t_{TimerDelay}$) needs to be set to a lower value than the trigger delay ($t_{triggerdelay}$).
- The duration ($t_{TimerDuration}$) of the timer signal should last until the exposure of the sensor is completed. This can be realized by using the following formula:

$$t_{TimerDuration} = (t_{triggerdelay} - t_{TimerDelay}) + t_{exposure}$$

4.6.7.2 Interruption Behaviour

Upon unintended faulty configuration, Baumer TXG cameras are able to interrupt running timers as displayed within the following figure.

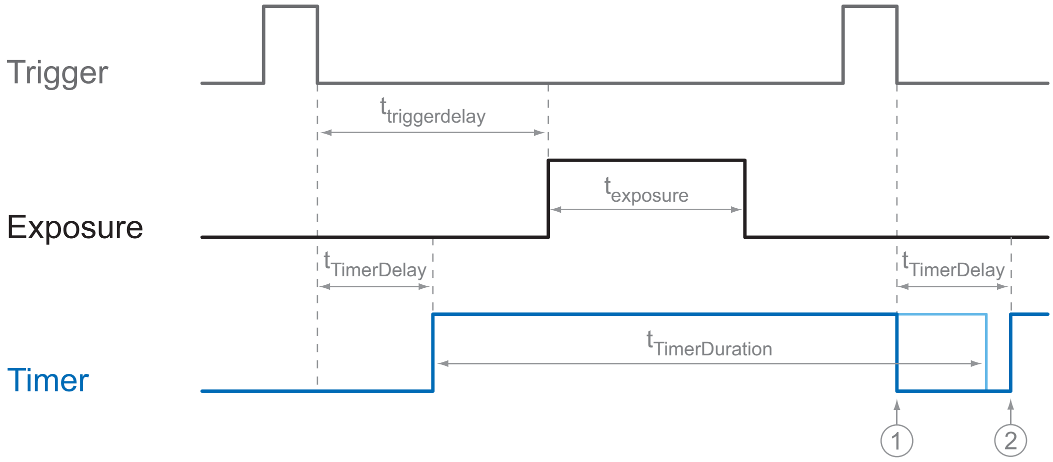


Figure 57 ▶ Interruption behaviour of the timer feature.

In case of incoming valid trigger signal during a running timer, the timer will be aborted (1) and restarted (2) after the predefined TimerDelay.

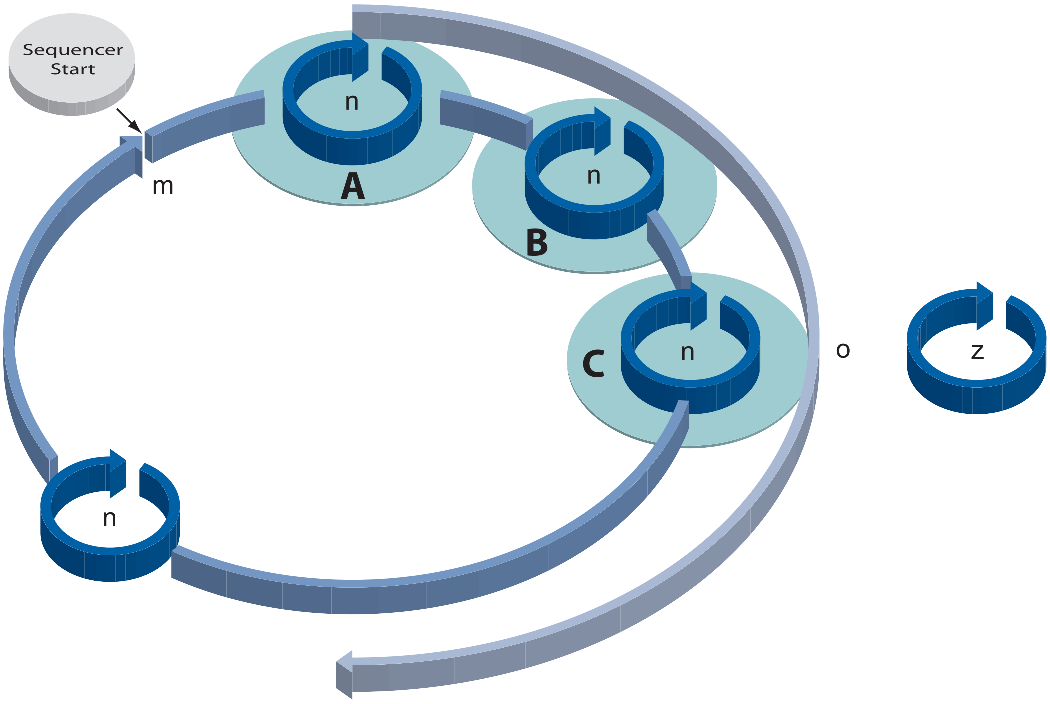
4.6.8 Frame Counter

The frame counter is part of the Baumer image infoheader and supplied with every image, if the chunkmode is activated. It is generated by hardware and can be used to verify that every image of the camera is transmitted to the PC and received in the right order.

4.7 Sequencer

4.7.1 General Information

A sequencer is used for the automated control of series of images using different sets of parameters.



◄ **Figure 58**
Flow chart of sequencer.
m - number of loop passes
n - number of set repetitions
o - number of sets of parameters
z - number of frames per trigger

The figure above displays the fundamental structure of the sequencer module.

A sequence (o) is defined as a complete pass through all sets of parameters.

The loop counter (m) represents the number of sequence repetitions.

The repeat counter (n) is used to control the amount of images taken with the respective sets of parameters.

Sequencer Parameter:

The mentioned sets of parameter include the following:

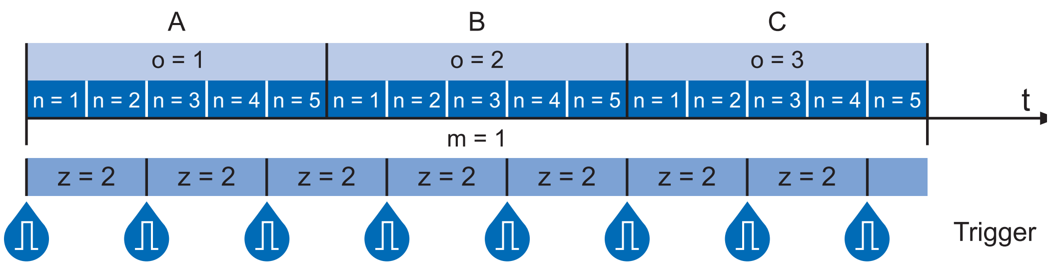
- *Exposure time*
- *Gain factor*

The start of the sequencer can be realized directly (free running) or via an external event (trigger).

The additional frame counter (z) is used to create a half-automated sequencer. It is absolutely independent from the other three counters, and used to determine the number of frames per external trigger event.

The following timeline displays the temporal course of a sequence with:

- n = 5 repetitions per set of parameters
- o = 3 sets of parameters (A,B and C)
- m = 1 sequence and
- z = 2 frames per trigger



◄ **Figure 59**
Timeline for a single sequence

4.7.2 Baumer Optronic Sequencer in Camera xml-file

The Baumer Optronic seqencer is described in the category "BOSequencer" by the following features:

<Category Name="BOSequencer" NameSpace="Custom">	
<pFeature>BoSequencerEnable</pFeature>	Enable / Disable
<pFeature>BoSequencerStart</pFeature>	Start / Stop
<pFeature>BoSequencerRunOnce</pFeature>	Run Once / Cycle
<pFeature>BoSequencerFreeRun</pFeature>	Free Running / Trigger
<pFeature>BoSequencerSetSelector</pFeature>	Configure set of parameters
<pFeature>BoSequencerLoops</pFeature>	Number of sequences (m)
<pFeature>BoSequencerSetRepeats</pFeature>	Number of repetitions (n)
<pFeature>BoSequencerFramesPerTrigger</pFeature>	Number of frames per trigger (z)
<pFeature>BoSequencerExposure</pFeature>	Parameter exposure
<pFeature>BoSequencerGain</pFeature>	Parameter gain
</Category>	

4.7.3 Sequencer Modes

The sequencer supports four different modes, which can be activated in the xml-file via a combination of features `BoSequencerRunOnce` and `BoSequencerFreeRun`:

Mode	Activation	Description
ONCE BY TRIGGER	BoSequencerRunOnce = 1 BoSequencerFreeRun = 0	The sequencer will run one complete cycle (m sequences). It is started by an incoming trigger event.
ONCE FREE	BoSequencerRunOnce = 1 BoSequencerFreeRun = 1	The sequencer will run one complete cycle (m sequences). It is started directly.
CYCLE BY TRIGGER	BoSequencerRunOnce = 0 BoSequencerFreeRun = 0	The sequencer will run continuously. It is started by an incoming trigger event.
CYCLE FREE	BoSequencerRunOnce = 0 BoSequencerFreeRun = 1	The sequencer will run continuously. It is started directly.

4.7.4 Modality

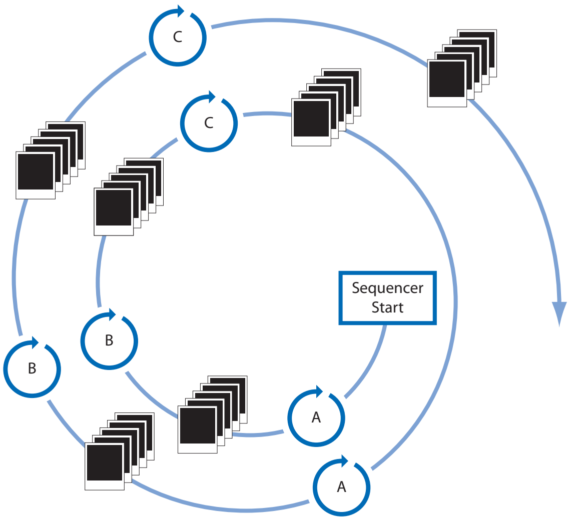
In general, the procedure of sequencer integration is:

a) Sequencer activation via `BoSequencerEnable`
b) Setting selector for "set of parameters" to minimum via `BoSequencerSetSelector`
c) Adjustment of parameters via `BoSequencerExposure` and `BoSequencerGain`
d) Setting sequencer run mode via `BoSequencerRunOnce` and `BoSequencerFreeRun`
e) Definitions of "set of parameters" repetition via `BoSequencerSetRepeats`
f) Adjustment of loop counter via `BoSequencerLoops`
g) Starting sequencer by `BoSequencerStart`

To indicate several sets of parameters, steps b) and c) should be repeated. Here it is important to number the selectors continously and leave no gaps in the numeration. The last configured set of parameters will also be last in the sequence.

4.7.5 Examples

4.7.5.1 Sequencer without Machine Cycle

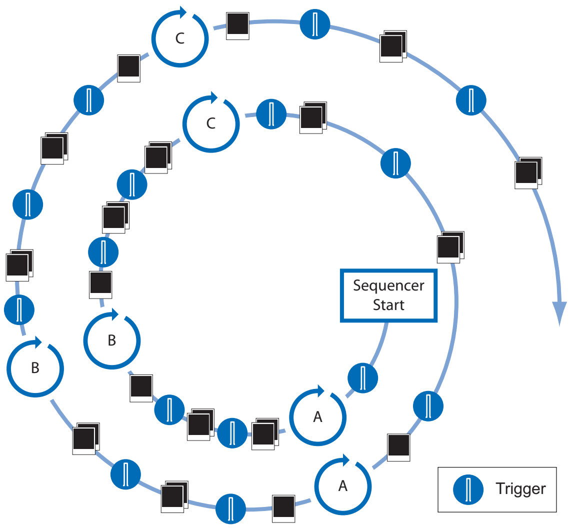


◄ **Figure 60**
Example for a fully automated sequencer.

The figure above shows an example for a fully automated sequencer with three sets of parameters (A,B and C). Here the repeat counter (n) is set to 5, the loop counter (m) has a value of 2.

When the sequencer is started, with or without an external event, the camera will record 5 images successively in each case, using the sets of parameters A, B and C (which constitutes a sequence). After that, the sequence is started once again, followed by a stop of the sequencer - in this case the parameters are maintained.

4.7.5.2 Sequencer Controlled by Machine Steps (trigger)



◄ **Figure 61**
Example for a half-automated sequencer.

The figure above shows an example for a half-automated sequencer with three sets of parameters (A,B and C) from the previous example. The frame counter (z) is set to 2. This means the camera records two pictures after an incoming trigger signal.

4.7.6 Capability Characteristics of Baumer-GAPI Sequencer Module

- up to 256 sets of parameters
- up to 4 billion loop passes
- up to 4 billion repetitions of sets of parameters
- up to 4 billion images per trigger event
- free running mode without initial trigger

4.7.7 Double Shutter

This feature offers the possibility of capturing two images in a very short interval. Depending on the application, this is performed in conjunction with a flash unit. Thereby the first exposure time ($t_{exposure}$) is arbitrary and accompanied by the first flash. The second exposure time must be equal to, or longer than the readout time ($t_{readout}$) of the sensor. Thus the pixels of the sensor are recepitve again shortly after the first exposure. In order to realize the second short exposure time without an overrun of the sensor, a second short flash must be employed, and any subsequent extraneous light prevented.

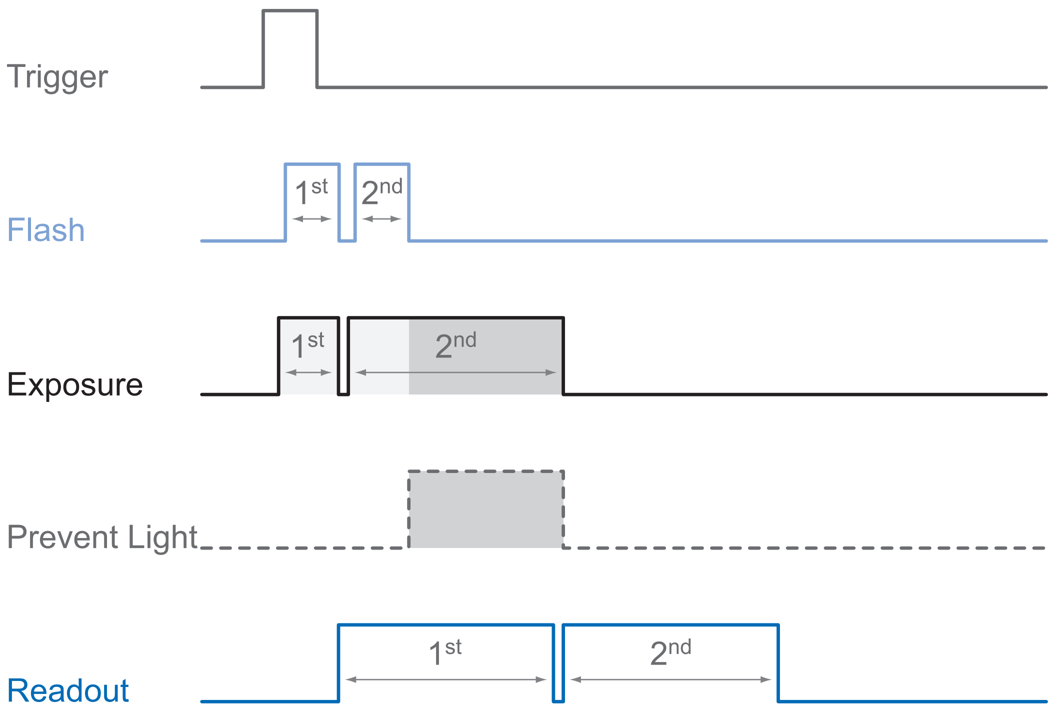


Figure 62 ▶
Example of a double shutter.

On Baumer TXG cameras this feature is realized within the sequencer.

In order to generate this sequence, the sequencer must be configured as follows:

Parameter	Setting:
Sequencer Run Mode	Once by Trigger
Sets of parameters (o)	2
Loops (m)	1
Repeats (n)	1
Frames Per Trigger (z)	2

4.8 User Sets

Four user sets (0-3) are available for the Baumer cameras of the TXG series. User set 0 is the default set and contains the factory settings. User sets 1 to 3 are user-specific and can contain the following information:

Parameter	Parameter
Binning	Image Format
Brightness Correction	Look-Up-Table
Defect Pixel Correction	Message Channel
Defectpixellist	Offset (Black Level)
Digital IOs	Partial Scan
Fast / HQ Mode	Pixel Format
Flash Settings	Sequencer
Gain	Trigger Settings
Exposure Time	

These user sets are stored within the camera and and cannot be saved outside the device.

By employing a so-called "user set default selector", one of the four possible user sets can be selected as default, which means, the camera starts up with these adjusted parameters.

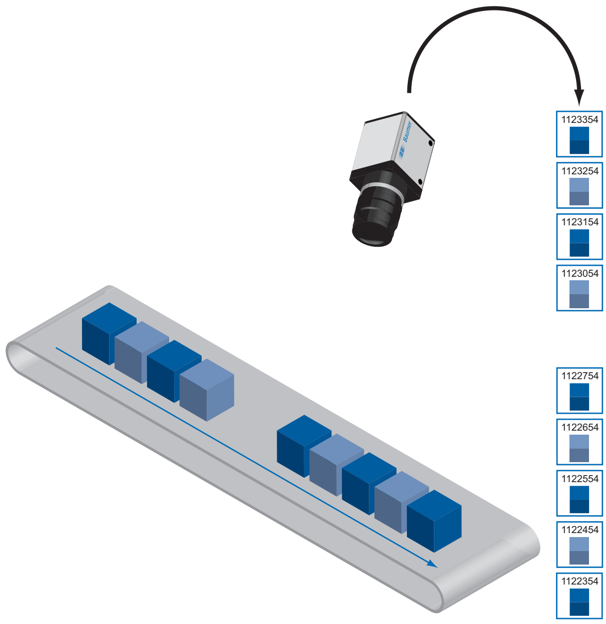
4.9 Factory Settings

The factory settings are stored in "user set 0" which is the default user set. This is the only user set, that is not editable.

4.10 Timestamp

The timestamp is part of the GigE Vision® standard. It is 64 bits long and denoted in Ticks*). Any image or event includes its corresponding timestamp.

At power on or reset, the timestamp starts running from zero.



◄ **Figure 63**
Timestamps of recorded images.

*) Tick is the internal time unit of the camera, it lasts 32 nsec.

5. Interface Functionalities

5.1 Device Information

This Gigabit Ethernet-specific information on the device is part of the Discovery-Acknowledge of the camera.

Included information:
- MAC address
- Current IP configuration (persistent IP / DHCP / LLA)
- Current IP parameters (IP address, subnet mask, gateway)
- Manufacturer's name
- Manufacturer-specific information
- Device version
- Serial number
- User-defined name (user programmable string)

5.2 Packet Size and Maximum Transmission Unit (MTU)

Network packets can be of different sizes. The size depends on the network components employed. When using GigE Vision®- compliant devices, it is generally recommended to use larger packets. On the one hand the overhead per packet is smaller, on the other hand larger packets cause less CPU load.

The packet size of UDP packets can differ from 576 Bytes up to the MTU.

The MTU describes the maximal packet size which can be handled by all network components involved.

In principle modern network hardware supports a packet size of 1500 Byte, which is specified in the network standard. However, so-called "Jumboframes" are on the advance as Gigabit Ethernet continues to spread. "Jumboframes" merely characterizes a packet size exceeding 1500 Bytes.

Baumer TXG cameras can handle a MTU of up to 65535 Bytes.

5.3 Inter Packet Gap

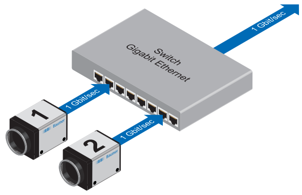
IPG:
The IPG is measured in ticks (described in chapter 5.2). *An easy rule of thumb is:* *1 Tick is equivalent to 4 Bytes of data.* *You should also not forget to add the various ethernet headers to your calculation.*

To achieve optimal results in image transfer, several Ethernet-specific factors need to be considered when using Baumer TXG cameras.

Upon starting the image transfer of a camera, the data packets are transferred at maximum transfer speed (1 Gbit/sec). In accordance with the network standard, Baumer employs a minimal separation of 12 Bytes between two packets. This separation is called "inter packet gap" (IPG). In addition to the minimal IPG, the GigE Vision® standard stipulates that the IPG be scalable (user-defined).

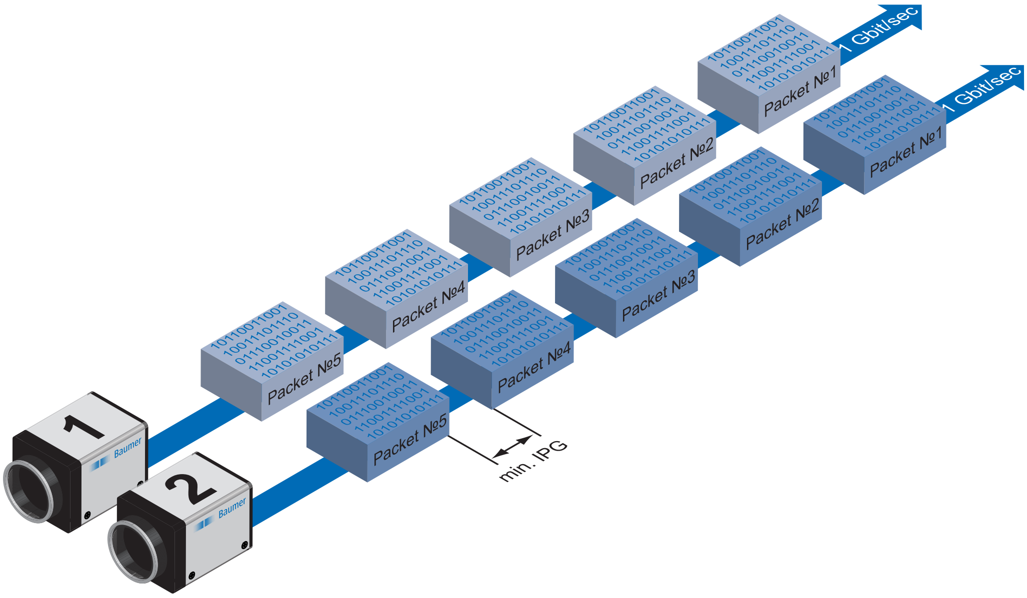
5.3.1 Example 1: Multi Camera Operation – Minimal IPG

Setting the IPG to minimum means every image is transfered at maximum speed. Even by using a frame rate of 1 fps this results in full load on the network. Such "bursts" can lead to an overload of several network components and a loss of packets. This can occur, especially when using several cameras.



▲ **Figure 64**
Operation of two cameras employing a Gigabit Ethernet switch.
Data processing within the switch is displayed in the next two figures.

In the case of two cameras sending images at the same time, this would theoretically occur at a transfer rate of 2 Gbits/sec. The switch has to buffer this data and transfer it at a speed of 1 Gbit/sec afterwards. Depending on the internal buffer of the switch, this operates without any problems up to n cameras (n ≥ 1). More cameras would lead to a loss of packets. These lost packets can however be saved by employing an appropriate resend mechanism, but this leads to additional load on the network components.



◄ **Figure 65**
Operation of two cameras employing a minimal inter packet gap (IPG).

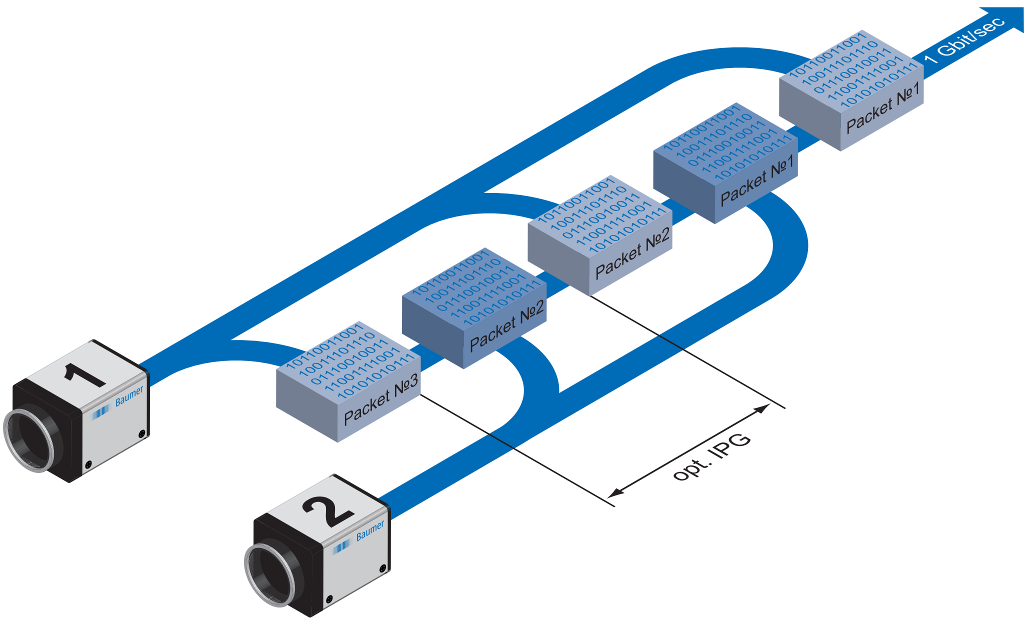
5.3.2 Example 2: Multi Camera Operation – Optimal IPG

A better method is to increase the IPG to a size of

optimal IPG = packet size + 2 × minimal IPG

In this way both data packets can be transferred successively (zipper principle), and the switch does not need to buffer the packets.

Max. IPG:
On the Gigabit Ethernet the max. IPG and the data packet must not exceed 1 Gbit. Otherwise data packets can be lost.



◄ **Figure 66**
Operation of two cameras employing an optimal inter packet gap (IPG).

5.4 Transmission Delay

Another approach for packet sorting in multi-camera operation is the so-called Transmission Delay, which was introduced to Baumer Gigabit Ethernet cameras in hardware release 2.1.

Due to the fact, that the currently recorded image is stored within the camera and its transmission starts with a predefined delay, complete images can be transmitted to the PC at once.

The following figure should serve as an example:

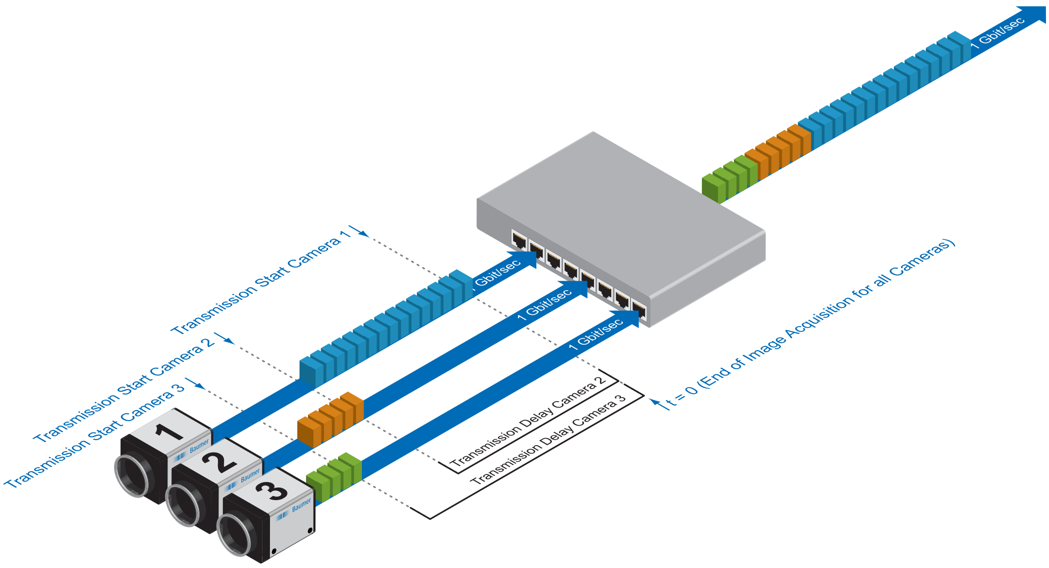


Figure 67 ▶
Principle of the transmission delay.

For the image processing three cameras with different sensor resolutions are employed – for example camera 1: TXG13, camera 2: TXG06, camera 3: TXG03.

Due to process-related circumstances, the image acquisitions of all cameras end at the same time. Now the cameras are not trying to transmit their images simultaniously, but – according to the specified transmission delays – subsequently. Thereby the first camera starts the transmission immediately – with a transmission delay "0".

5.4.1 Time Saving in Multi-Camera Operation

As previously stated, the transmission delay feature was especially designed for multi-camera operation with employment of different camera models. Just here an significant acceleration of the image transmission can be achieved:

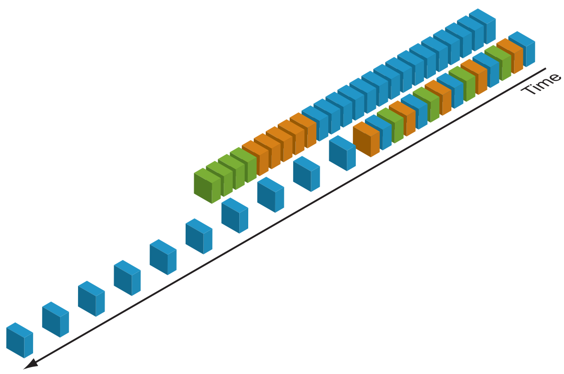


Figure 68 ▶
Comparison of transmission delay and inter packet gap, employed for a multi-camera system with different camera models.

For the above mentioned example, the employment of the transmission delay feature results in a time saving – compared to the approach of using the inter paket gap – of approx. 45% (applied to the transmission of all three images).

5.4.2 Configuration Example

For the three employed cameras the following data are known:

Camera Model	Sensor Resolution	Pixel Format (Pixel Depth)	Resulting Data Volume	Readout Time	Exposure Time	Transfer Time (GigE)
	[Pixel]	[bit]	[bit]	[msec]	[msec]	[msec]
TXG13	1392 x 1040	8	11581440	50	32	≈ 10.8
TXG06	776 x 582	8	3613056	15.5	32	≈ 3.4
TXG03	656 x 494	8	2592512	11	32	≈ 2.4

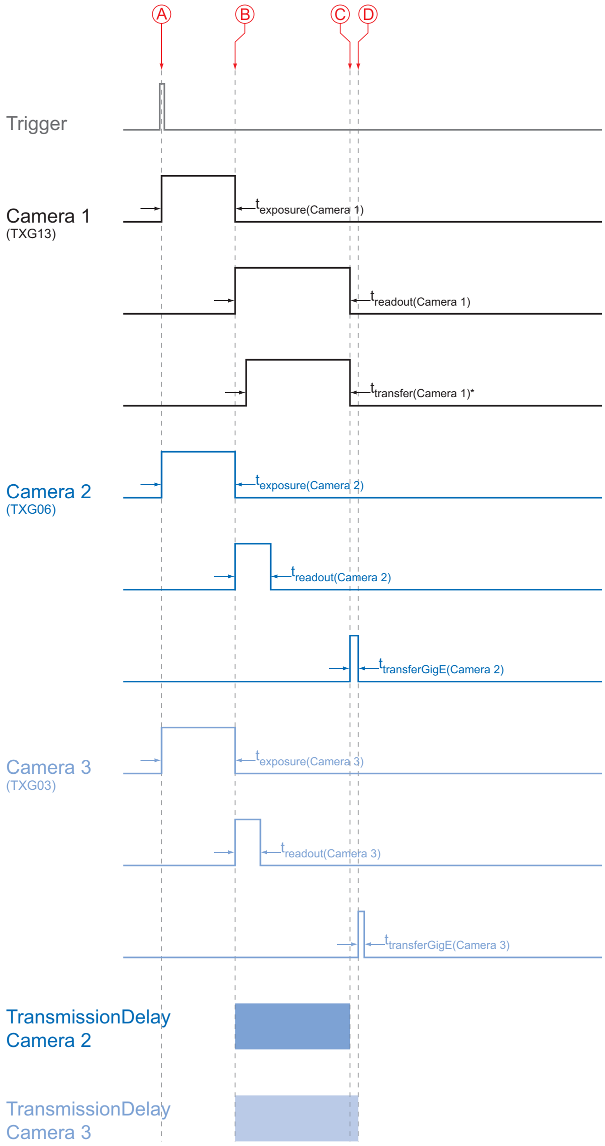
- The sensor resolution and the readout time ($t_{readout}$) can be found in the respective Technical Data Sheet (TDS). For the example a full frame resolution is used.
- The exposure time ($t_{exposure}$) is manually set to 32 msec.

- The resulting data volume is calculated as follows:
  Resulting Data Volume = horizontal Pixels × vertical Pixels × Pixel Depth

- The transfer time ($t_{transferGigE}$) for full GigE transfer rate is calculated as follows:
  Transfer Time (GigE) = Resulting Data Volume / 1024³ × 1000 [msec]

All the cameras are triggered simultaniously.

The transmission delay is realized as a counter, that is started immediately after the sensor readout is started.



Timings:
A - exposure start for all cameras
B - all cameras ready for transmission
C - transmission start camera 2
D - transmission start camera 3

** Due to technical issues the data transfer of camera 1 does not take place with full GigE speed.*

◄ **Figure 69**
Timing diagram for the transmission delay of the three employed cameras, using even exposure times.

In general, the transmission delay is calculated as:

$$t_{TransmissionDelay(Camera\ n)} = t_{exposure(Camera\ 1)} + t_{readout(Camera\ 1)} - t_{exposure(Camera\ n)} + \sum_{n \geq 3}^{n} t_{transferGigE(Camera\ n\ \ 1)}$$

Therewith for the example, the transmission delays of camera 2 and 3 are calculated as follows:

$$t_{TransmissionDelay(Camera\ 2)} = t_{exposure(Camera\ 1)} + t_{readout(Camera\ 1)} - t_{exposure(Camera\ 2)}$$

$$t_{TransmissionDelay(Camera\ 3)} = t_{exposure(Camera\ 1)} + t_{readout(Camera\ 1)} - t_{exposure(Camera\ 3)} + t_{transferGige(Camera\ 2)}$$

Solving this equations leads to:

$$\begin{aligned} t_{TransmissionDelay(Camera\ 2)} &= 32\ msec + 50\ msec - 32\ msec \\ &= 50\ msec \\ &= 1562500\ Ticks \end{aligned}$$

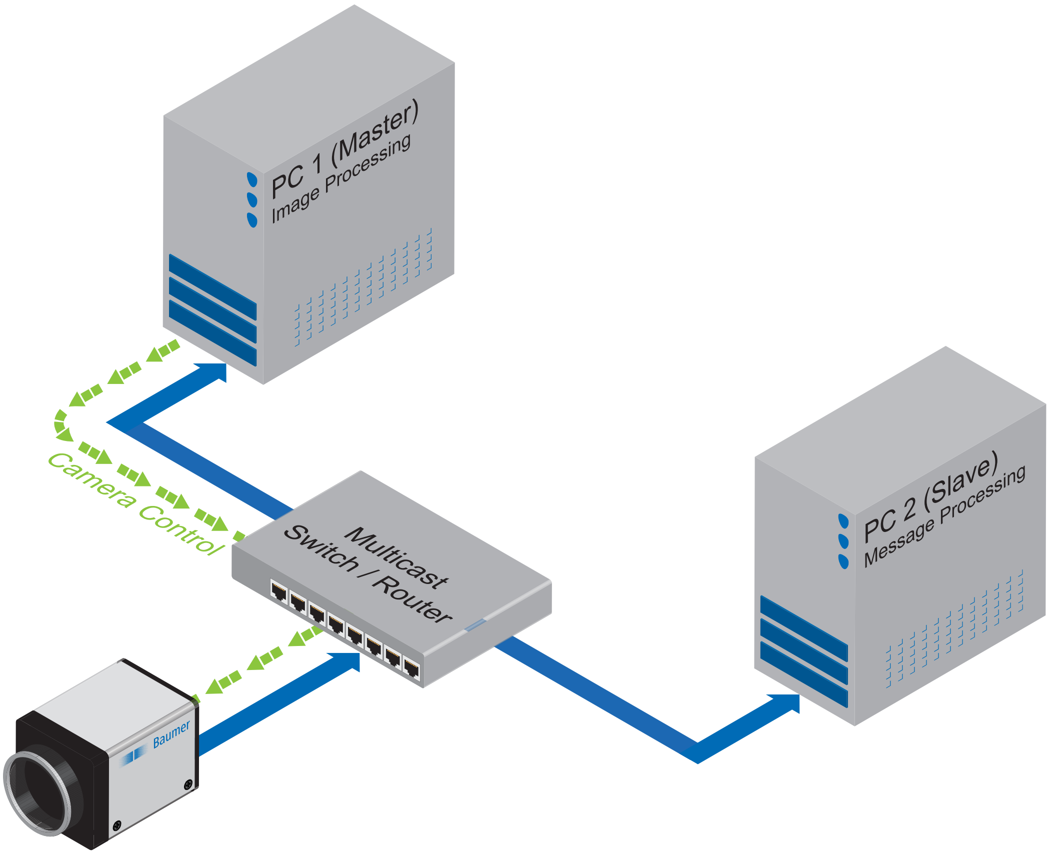
$$\begin{aligned} t_{TransmissionDelay(Camera\ 3)} &= 32\ msec + 50\ msec - 32\ msec + 2.4\ msec \\ &= 52.4\ msec \\ &= 1637500\ Ticks \end{aligned}$$

5.5 Multicast

Multicasting offers the possibility to send data packets to more than one destination address – without multiplying bandwidth and number of receivers on sender side. The data is sent out to an intelligent network node, an IGMP (Internet Group Management Protocol) capable switch or router and distributed to the receiver group.

On Baumer Gigabit Ethernet cameras, multicast is used to process image and message date separately – on e.g. two different PC's.

Multicast Addresses:
For multicasting Baumer suggests an IP range from 232.0.1.0 to 232.255.255.255.



◄ **Figure 70**
Multicasting with one Baumer Gigabit Ethernet camera and two PC's.

Internet Protocol:
On Baumer cameras IP v4 is employed.

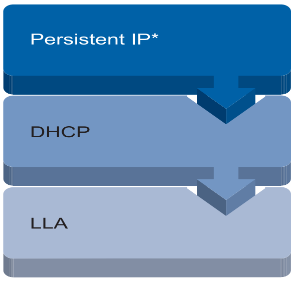


Figure 71 ▲
Connection pathway for Baumer Gigabit Ethernet cameras:
The device connects step by step via the three described mechanisms.

5.6 IP Configuration

5.6.1 Persistent IP

A persistent IP adress is assigned permanently. Its validity is unlimited.

Notice

Please ensure a valid combination of IP address and subnet mask.

IP range:	Subnet mask:
0.0.0.0 – 127.255.255.255	255.0.0.0
128.0.0.0 – 191.255.255.255	255.255.0.0
192.0.0.0 – 223.255.255.255	255.255.255.0

These combinations are not checked by Baumer-GAPI, Baumer-GAPI Viewer or camera on the fly. This check is performed when restarting the camera, in case of an invalid IP - subnet combination the camera will start in LLA mode.

* This feature is disabled by default.

5.6.2 DHCP (Dynamic Host Configuration Protocol)

DHCP:
Please pay attention to the DHCP Lease Time.

The DHCP automates the assignment of network parameters such as IP addresses, subnet masks and gateways. This process takes up to 12 sec.

Once the device (client) is connected to a DHCP-enabled network, four steps are processed:

- DHCP Discovery
  In order to find a DHCP server, the client sends a so called DHCPDISCOVER broadcast to the network.

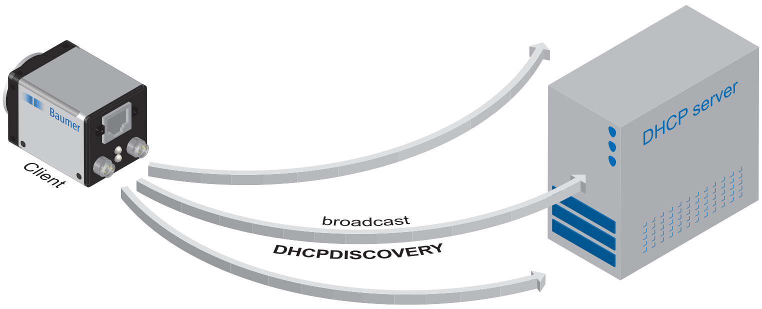


Figure 72 ►
DHCP Discovery (broadcast)

- DHCP Offer
  After reception of this broadcast, the DHCP server will answer the request by a unicast, known as DHCPOFFER. This message contains several items of information, such as:

Information for the client	MAC address
	offered IP address
Information on server	IP adress
	subnet mask
	duration of the lease

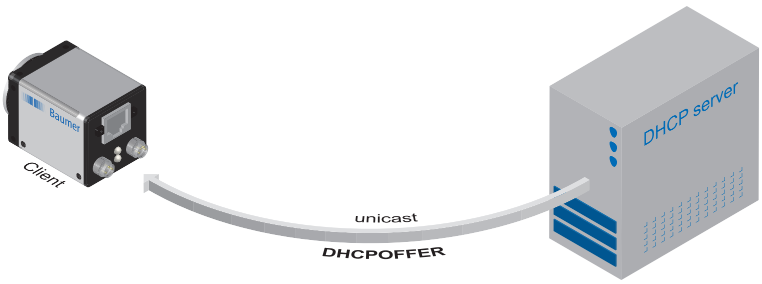
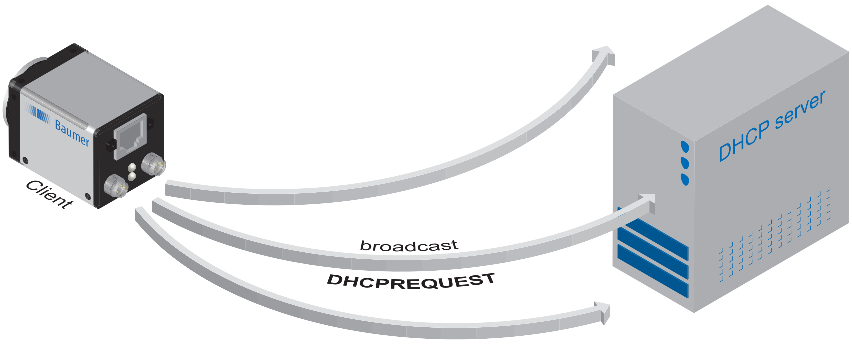


Figure 71 ►
DHCP offer (unicast)

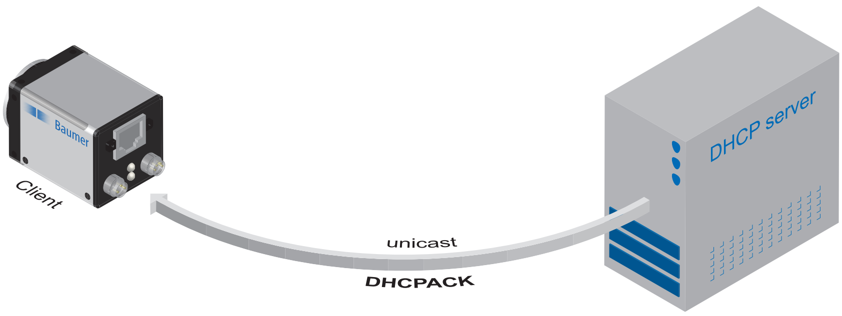
- DHCP Request
  Once the client has received this DHCPOFFER, the transaction needs to be confirmed. For this purpose the client sends a so called DHCPREQUEST broadcast to the network. This message contains the IP address of the offering DHCP server and informs all other possible DHCPservers that the client has obtained all the necessary information, and there is therefore no need to issue IP information to the client.



◄ **Figure 73**
DHCP Request (broadcast)

- DHCP Acknowledgement
  Once the DHCP server obtains the DHCPREQUEST, a unicast containing all necessary information is sent to the client. This message is called DHCPACK.
  According to this information, the client will configure its IP parameters and the process is complete.

DHCP Lease Time:
The validity of DHCP IP addresses is limited by the lease time. When this time is elapsed, the IP configuration needs to be redone. This causes a connection abort.



◄ **Figure 74**
DHCP Acknowledgement (unicast)

5.6.3 LLA

LLA:
Please ensure operation of the PC within the same subnet as the camera.

LLA (Link-Local Address) refers to a local IP range from 169.254.0.1 to 169.254.254.254 and is used for the automated assignment of an IP address to a device when no other method for IP assignment is available.

The IP address is determined by the host, using a pseudo-random number generator, which operates in the IP range mentioned above.

Once an address is chosen, this is sent together with an ARP (Address Resolution Protocol) query to the network to to check if it already exists. Depending on the response, the IP address will be assigned to the device (if not existing) or the process is repeated. This method may take some time - the GigE Vision® standard stipulates that establishing connection in the LLA should not take longer than 40 seconds, in the worst case it can take up to several minutes.

5.6.4 Force IP*)

Inadvertent faulty operation may result in connection errors between the PC and the camera. In this case "Force IP" may be the last resort. The Force IP mechanism sends an IP address and a subnet mask to the MAC address of the camera. These settings are sent without verification and are adapted immediately by the client. They remain valid until the camera is de-energized.

*) In the GigE Vision® standard, this feature is defined as "Static IP".

5.7 Packet Resend

Due to the fact, that the GigE Vision® standard stipulates using a UDP - a stateless user datagram protocol - for data transfer, a mechanism for saving the "lost" data needs to be employed.

Here, a resend request is initiated if one or more packets are damaged during transfer and - due to an incorrect checksum - rejected afterwards.

On this topic one must distinguish between three cases:

5.7.1 Normal Case

In the case of unproblematic data transfer, all packets are transferred in their correct order from the camera to the PC. The probability of this happening is more then 99%.

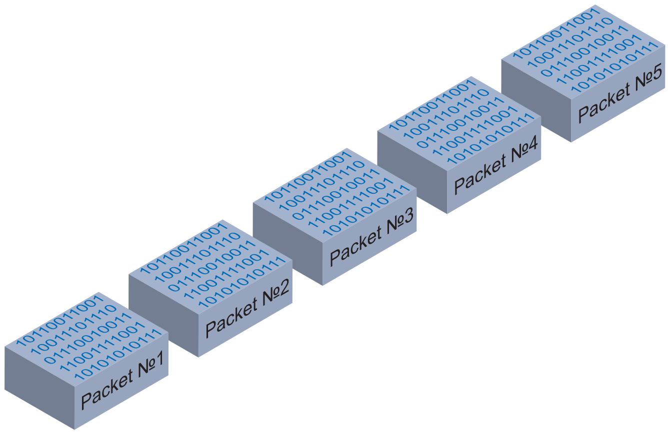


Figure 75 ▶
Data stream without damaged or lost packets.

5.7.2 Fault 1: Lost Packet within Data Stream

If one or more packets are lost within the data stream, this is detected by the fact, that packet number n is not followed by packet number (n+1). In this case the application sends a resend request (A). Following this request, the camera sends the next packet and then resends (B) the lost packet.

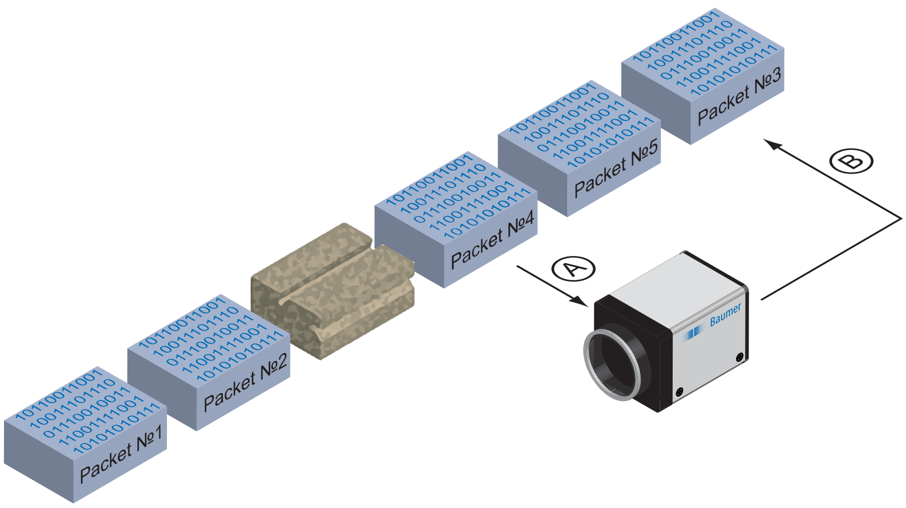
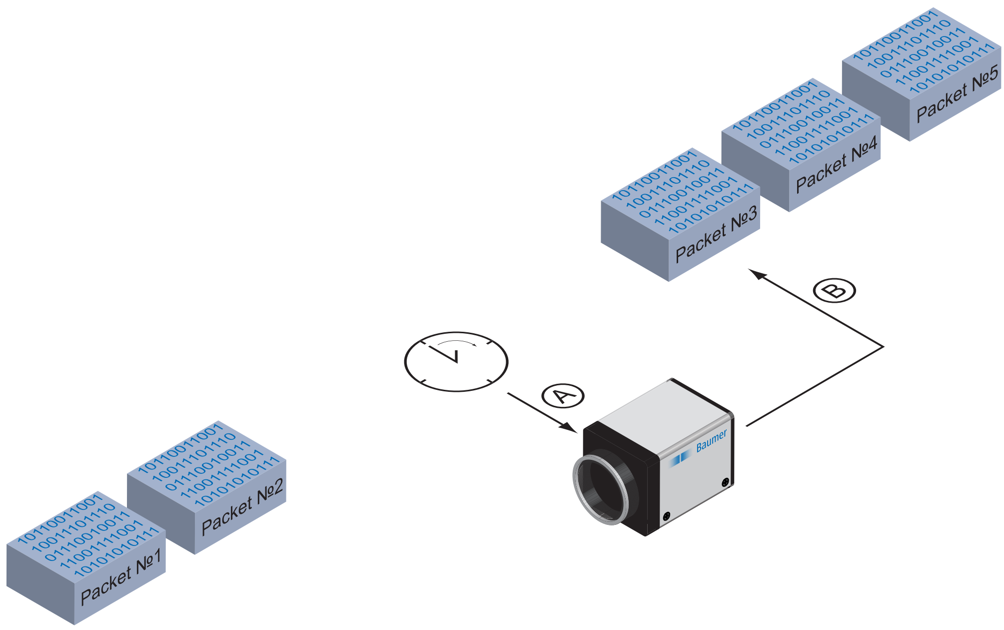


Figure 76 ▶
Resending lost packets within the data stream.

In our example packet no. 3 is lost. This fault is detected on packet no. 4, and the resend request triggered. Then the camera sends packet no. 5, followed by resending packet no. 3.

5.7.3 Fault 2: Lost Packet at the End of the Data Stream

In case of a fault at the end of the data stream, the application will wait for incoming packets for a predefined time. When this time has elapsed, the resend request is triggered and the "lost" packets will be resent.



◄ **Figure 77**
Resending of lost packets at the end of the data stream.

In our example, packets from no. 3 to no. 5 are lost. This fault is detected after the predefined time has elapsed and the resend request (A) is triggered. The camera then resends packets no. 3 to no. 5 (B) to complete the image transfer.

5.7.4 Termination Conditions

The resend mechanism will continue until:
- all packets have reached the pc
- the maximum of resend repetitions is reached
- the resend timeout has occured or
- the camera returns an error.

5.8 Message Channel

The asynchronous message channel is described in the GigE Vision® standard and offers the possibility of event signaling. There is a timestamp (64 bits) for each announced event, which contains the accurate time the event occurred. Each event can be activated and deactivated separately.

5.8.1 Event Generation

Event	Description
Gen<i>Cam™	
ExposureStart	Exposure started
ExposureEnd	Exposure ended
FrameStart	Acquisition of a frame started
FrameEnd	Acquisition of a frame ended
Line0Rising	Rising edge detected on IO-Line 0
Line0Falling	Falling edge detected on IO-Line 0
Line1Rising	Rising edge detected on IO-Line 1
Line1Falling	Falling edge detected on IO-Line 1
Line2Rising	Rising edge detected on IO-Line 2
Line2Falling	Falling edge detected on IO-Line 2
Line3Rising	Rising edge detected on IO-Line 3
Line3Falling	Falling edge detected on IO-Line 3
Line4Rising	Rising edge detected on IO-Line 4
Line4Falling	Falling edge detected on IO-Line 4
Line5Rising	Rising edge detected on IO-Line 5
Line5Falling	Falling edge detected on IO-Line 5
Vendor-specific	
EventError	Error in event handling
EventLost	Occured event not analyzed
TemperatureExceeded	Reference value of temperature exceeded
TriggerReady	$t_{notready}$ (see chapter 2.4) elapsed, camera is able to process incoming trigger
TriggerOverlapped	Overlapped Mode (see chapter 2.4) detected
TriggerSkipped	Camera overtriggered (see chapter 2.4)
EndOfSequencerExposure	Last exposure of sequence ended

5.9 Action Command / Trigger over Ethernet

The basic idea behind this feature was to achieve a simultaneous trigger for multiple cameras.

Therefore a broadcast ethernet packet was implemented. This packet can be used to induce a trigger as well as other actions.

Due to the fact that different network components feature different latencies and jitters, the trigger over the Ethernet is not as synchronous as a hardware trigger. Nevertheless, applications can deal with these jitters in switched networks, and therefore this is a comfortable method for synchronizing cameras with software additions.

The action command is sent as a broadcast. In addition it is possible to group cameras, so that not all attached cameras respond to a broadcast action command.

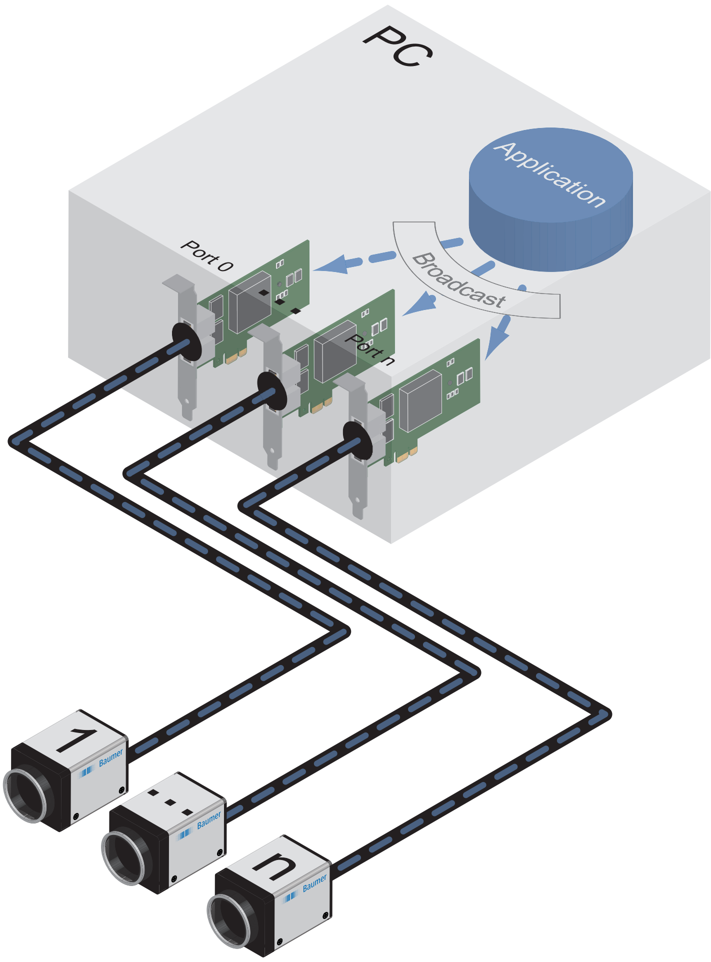
Such an action command contains:

- a Device Key - for authorization of the action on this device
- an Action ID - for identification of the action signal
- a Group Key - for triggering actions on separated groups of devices
- a Group Mask - for extension of the range of separate device groups

Action Command:
Since hardware release 2.1 the implemetation of the Action Command follows the regulations of the GigE Vision® standard 1.2.

5.9.1 Example: Triggering Multiple Cameras

The figure below displays three cameras, which are triggered synchronously by a software application.



◄ **Figure 78**
Triggering of multiple cameras via trigger over Ethernet (ToE).

Another application of action command is that a secondary application or PC or one of the attached cameras can actuate the trigger.

6. Start-Stop-Behaviour

6.1 Start / Stop Acquisition (Camera)

Once the image acquisition is started, three steps are processed within the camera:

- Determination of the current set of image parameters
- Exposure of the sensor
- Readout of the sensor.

Afterwards a repetition of this process takes place until the camera is stopped.

Stopping the acquisition means that the process mentioned above is aborted. If the stop signal occurs within a readout, the current readout will be finished before stopping the camera. If the stop signal arrives within an exposure, this will be aborted.

Special Case: Asynchronous Reset

Asynchronous Reset:
For further information on the timings of this feature, please see the respective data sheets.

The asynchronous reset represents a special case of stopping the current acquisition. Thereby exposure is aborted immediately. Thus the current image is not read out and the image is upcasted.

This feature was introduced to accelerate the changing of image parameters.

6.2 Start / Stop Interface

Without starting the interface, transmission of image data from the camera to the PC will not proceed. If the image acquisition is started befor the interface is activated, the recorded images are lost.

If the interface is stopped during a transmission, this is aborted immediately.

6.3 Pause / Resume Interface

Pausing while the interface is operational, results in an interim storage of the recorded images within the internal buffer of the camera.

After resuming the interface, the buffered image data will be transferred to the PC.

6.4 Acquisition Modes

In general, three acquisition modes are available for the cameras in the Baumer TXG series.

6.4.1 Free Running

Free running means the camera records images continuously without external events.

6.4.2 Trigger

The basic idea behind the trigger mode is the synchronization of cameras with machine cycles. Trigger mode means that image recording is not continuous, but triggered by external events.

This feature is described in chapter 4.6. Process Interface.

6.4.3 Sequencer

A sequencer is used for the automated control of series of images, using different settings for exposure time and gain. This feature is described in chapter 4.7.

7. Lens Mounting

Notice

Avoid contamination of the sensor and the lens by dust and airborne particles when mounting a lens to the device!

Therefore the following points are very important:

- Install lenses in an environment that is as dust free as possible!
- Keep the dust covers on camera and lens as long as possible!
- Hold the camera downwards with unprotected sensor (or filter- /cover glass)!
- Avoid contact with any optical surface of the camera or lens!

8. Cleaning

Cover glass

Notice

The sensor is mounted dust-proof. Remove of the cover glass for cleaning is not necessary.

Avoid cleaning the cover glass of the CCD sensor if possible. To prevent dust, follow the instructions under "Install lens".

If you must clean it, use compressed air or a soft, lint free cloth dampened with a small quantity of pure alcohol.

Housing

Caution!

Volatile solvents for cleaning.
Volatile solvents damage the surface of the camera.
Never use volatile solvents (benzine, thinner) for cleaning!

To clean the surface of the camera housing, use a soft, dry cloth. To remove persistent stains, use a soft cloth dampened with a small quantity of neutral detergent, then wipe dry.

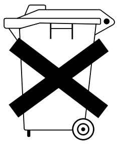
9. Transport / Storage

Notice

Transport the camera only in the original packaging. When the camera is not installed, then storage the camera in original packaging.

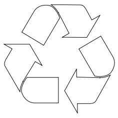
Storage Environment	
Storage temperature	-10°C ... +70°C (+14°F ... +158°F)
Storage Humidy	10% ... 90% non condensing

10. Disposal



Dispose of outdated products with electrical or electronic circuits, not in the normal domestic waste, but rather according to your national law and the directives 2002/96/EC and 2006/66/EC for recycling within the competent collectors.

Through the proper disposal of obsolete equipment will help to save valuable resources and prevent possible adverse effects on human health and the environment.



The return of the packaging to the material cycle helps conserve raw materials an reduces the production of waste. When no longer required, dispose of the packaging materials in accordance with the local regulations in force.

Keep the original packaging during the warranty period in order to be able to pack the device properly in the event of a warranty claim.

11. Warranty Notes

Notice

There are no adjustable parts inside the camera!

In order to avoid the loss of warranty do not open the housing!

Notice

If it is obvious that the device is / was dismantled, reworked or repaired by other than Baumer technicians, Baumer Optronic will not take any responsibility for the subsequent performance and quality of the device!

12. Conformity

Cameras of the Baumer TXG family comply with:

- CE,
- FCC Part 15 Class B,
- UL,
- RoHS

12.1 CE

We declare, under our sole responsibility, that the previously described Baumer TXG cameras conform with the directives of the CE.

12.2 FCC – Class B Device

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructios, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occure in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off an on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

12.3 UL – Class III Device

Power supply for operation of the TXG series of cameras must be provided using a limited power supply in accordance with UL60950.

13. Support

If you have any problems with the camera, then feel free to contact our support.

Worldwide

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